THE CP/M USER'S JOURNAL

$2.95

Microsystems

Volume 4 / Number 4

April 1983

Ways to use micros for gathering experimental data in the lab –direct connection or the IEEE-488 bus?

The IEEE-488 Bus in the Lab

Richard Newrock explains the facilities provided by the IEEE-488 General Purpose Interface Bus (GPIB), with practical guidance on design considerations affecting its use. In a second article, Richard Newrock gives a detailed review of the Pickles & Trout S-100/IEEE-488 interface board and its accompanying packages.

Other Instrumentation Interfaces

Joseph Long describes instrumentation interfaces developed to introduce chemistry students to computerization in the lab.

Ralph Place and Kirk Bailey discuss the problems encountered in bringing up a CP/M-86 on the STD bus for digitizer analysis of photographic material.

More on CP/M Plus

Bruce Ratoff concludes his two-part discussion of the advanced features of CP/M Plus.

Software Reviews

Chris Terry reviews utilities from Norway, as well as POWER (which replaces DDT, STAT, and other CP/M functions) and a keyboard redefinition program.

Hardware Review

Ernest Mau gives an in-depth review of the Morrow Designs' Decision 1, a versatile S-100 system in the middle price range.

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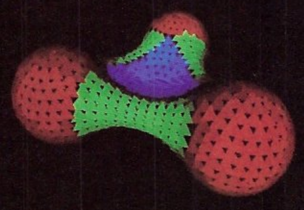
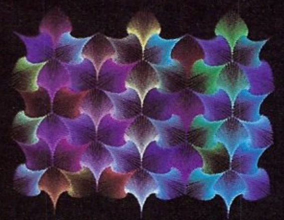
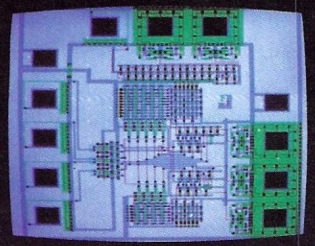


"Three Atoms" Courtesy of Greg Abram, University of North Carolina at Chapel Hill



"Aurora" By Richard Katz, Vectrix Corporation



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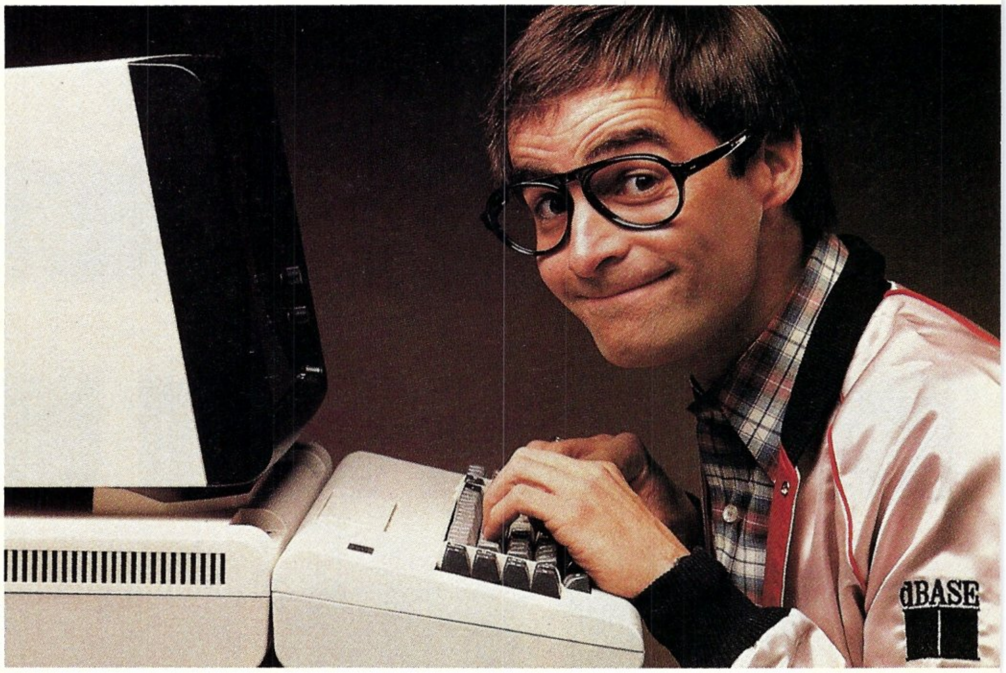

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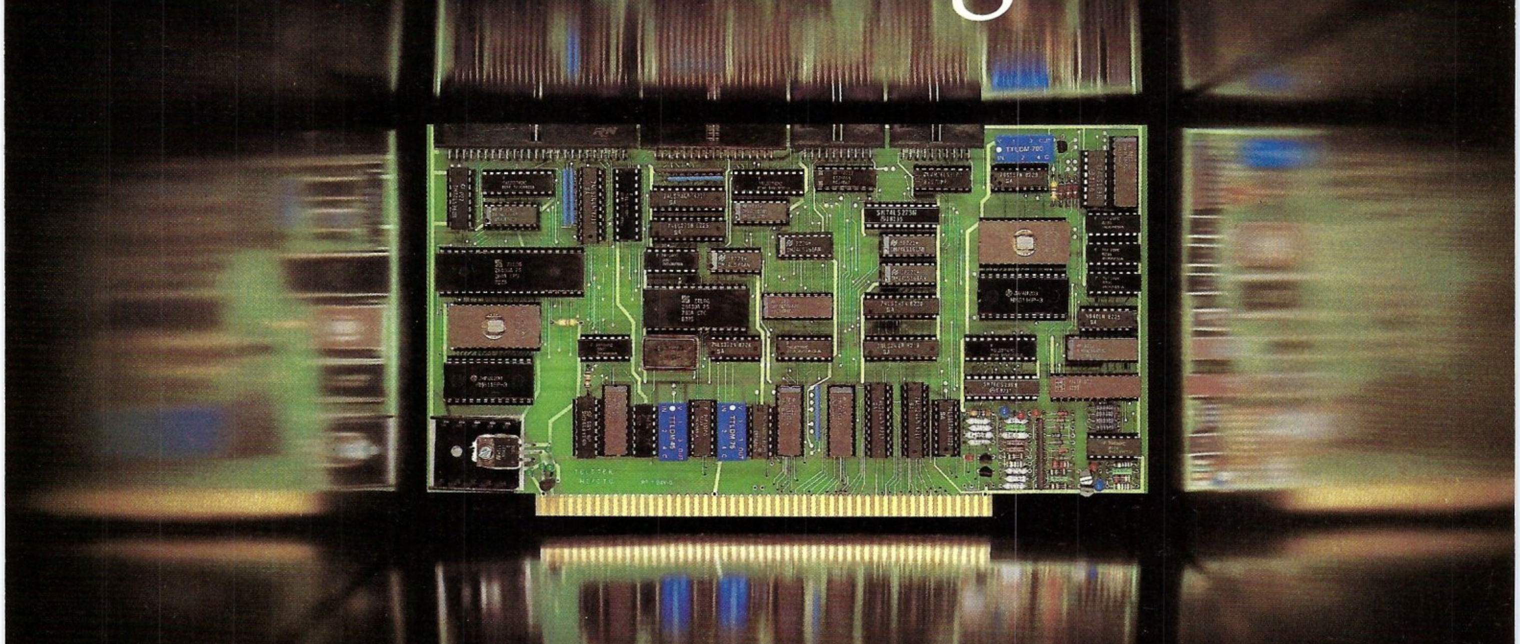

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Microsystems

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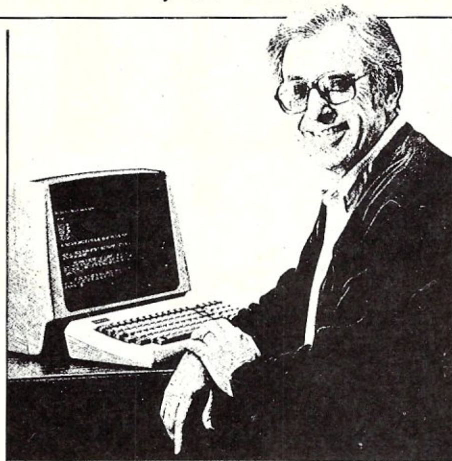
Editor's Page

by Sol Libes

It is with great pleasure that I can tell you that *Microsystems* magazine is doing really well. Total circulation is now approaching 50,000 with approximately one-third in dealer/newsstand sales and the rest direct subscribers. It must mean that we are doing things right . . . in other words, serving the needs of our readers. And we expect to continue as the leading magazine for the sophisticated user of microcomputer systems.

Incidentally, *Microsystems* is having its circulation figures audited by the publishing industry's independent auditing organization. So you can believe that our figures are accurate.

Also, we are in the process of conducting another of our reader surveys. We have selected 2,000 subscribers at random and mailed them our questionnaire and a one-dollar bill. If you are one of the lucky recipients of the questionnaire . . . congratulations . . . but please fill it out and return it to us. We really read your comments



and they provide a terrific feedback to us on how to improve *Microsystems*.

You may have also noticed that we have finally gotten our act together and are getting issues out on time . . . in fact we are getting them in the mails so that they have been arriving in subscriber's mailboxes by the first of the month. And we have done that while going from bimonthly to monthly publication. We think that is quite an accomplishment.

Upcoming issues

We are working on some terrific issues that will highlight the following topics:

May ....S-100 Standard & Components Directory
June .... Computer Graphics
July .... Business Oriented Software
August .... Computer Communications
September .... 16-bit Systems
October .... UNIX On Micros - Part II
November .... Local Area Networks

The photo below were taken at a breakfast meeting of RCPM Sysops and public domain software groups. The meeting, sponsored by *Microsystems*, was held in conjunction with CP/M-83 (San Francisco, Jan. 20-23, 1983). An article on what took place will appear in the May issue.

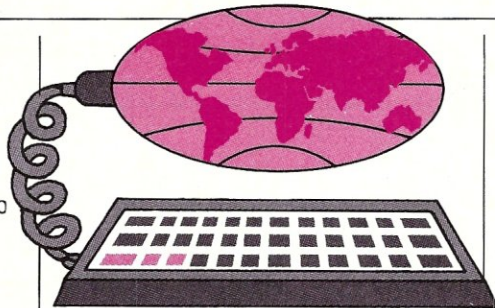
Above left: Ward Christensen (CPMUG software librarian).

Above right: Sol Libes (standing), Ward Christensen, Bill Bolton (CPMUG, Australia), Trevor Howard. **Below rt:** Bruce Ratoff, Bill Chin, Robert Todd (SIG/M Coordinators).

News & Views

by Sol Libes

Rumors. . . .
It is expected that at next month's National Computer Conference, at least 20 companies will introduce UNIX systems based on the 68000 and 80286. Also, expect at least two companies to show prototypes of high-capacity optical read/write systems. Moreover, several other companies can be expected to introduce portable computers: Rumors are that both Tandy and IBM will bring out portable machines. And, look for Osborne to introduce their two new portables: One, a lower-cost unit weighing 40% less than the current unit, and the second, having a 9″ display instead of the current 5-incher. Expect both to have some form of IBM-PC compatibility. . . . There are rumors that Memotech, a manufacturer of peripherals for the Sinclair ZX81/Timex 1000, will shortly introduce a 5¼″ disk drive add-on



for the ZX81 that will include CP/M and an enhanced keyboard. They are expected to sell it for $300. Add some additional memory, and you should be able to have a minimal CP/M system for under $800.

Computer hobbyists to meet
Over 15,000 avid computer hobbyists are expected at the Trenton Computer Festival on April 16 and 17. The big attraction is an outdoor flea market that covers about 20 acres, where hobbyists can buy everything from complete used computer systems and components to used software and rare out-of-print manuals. Sellers and traders set up tables and sell off the back of their cars.

Called the "Trenton Computer Festival," it is now in its eighth year and has the distinction of being the first personal computer show ever held. It is held on the campus of Trenton State College, Trenton, New Jersey. There will also be an indoor commercial exhibitor area, speakers, user group meetings, and a banquet.

The Trenton Computer Festival is sponsored by three nonprofit organizations: The Amateur Computer Group of New Jersey, Philadelphia Area Computer Society, and Trenton State Computer Society. For information call (609) 771-2487 or write: TCF-83, Trenton State College, Trenton NJ 08625.

UNIX/C CBBS starts

C-LINE, A Computer Bulletin Board System supporting UNIX/C users is now in operation (2000-0900 hours weekdays, 24 hours weekends; 110-710 baud). The phone number is (201) 625-1797, and the sysop is David Fiedler (who has authored several articles on UNIX AND C for *Microsystems*). The system is running CP/M-Microshell with 2 Mbytes of files. It caters to news and rumors about UNIX, UNIX-like systems, and C software. The sysop promises online instruction in UNIX and C.

Public domain software

The SIG/M software group has released volumes 85 through 91, containing new utilities and the SYSLIB integrated library of macros.

These disks are available on many RCPM systems and local CP/M user groups or from SIG/M, Box 97, Iselin, NJ 08830.

Audio/Visuals . . .

Bell Laboratories is offering two videotapes on the UNIX operating system. One gives an overview and shows how it is used. The second gives more details on UNIX. The cassette tapes are $100 VHS/Beta) or $140 (PAL/SECAM). They are available from MGS Services, Inc., 619 W. 54th St., NY, NY 10019.

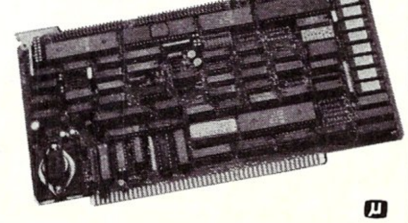
The SIGGRAPH (Special Interest Group on Computer Graphics) of ACM (Association for Computing Machinery) has available 35-mm slides and video tapes on computer-generated graphics. For more information conctact: Tom DeFanti, UICC/EECS, Box 4348, Chicago, IL 60680; (312) 996-5485.

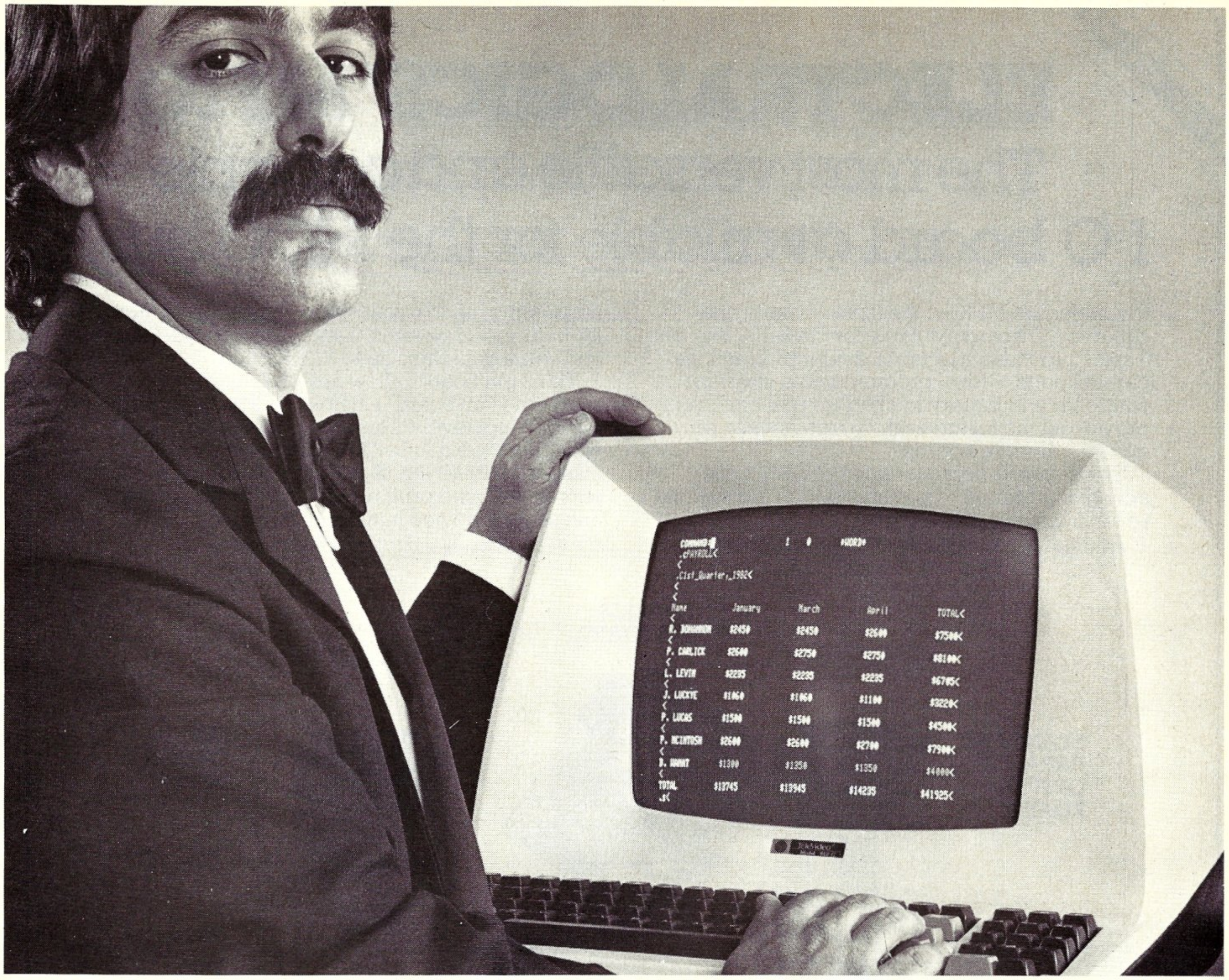
News bits . . .

Digital Equipment Corp. (DEC) has agreed to distribute the Bridge software package from Virtual Microsystems. The Bridge allows CP/M-based software to run on DEC minicomputers. . . . Digital Research is expected to shortly introduce a Fortran Compiler. . . A new magazine for UNIX and C users is being published by World UNIX & C, 30 Mowry St., Box 5314, Mt. Carmel, CT 06518; tel: (203) 288-0283. A subscription is $12/year ($16 if invoiced).

Erratum

In "Four SBCs Reviewed" (Feb '83), the price of the Intercontinental Micro Systems board in Table 1, p. 75 should be $995, not $1025. Also, we inadvertently showed a second view of the Sierra SBC-100 board instead of the Advanced Digital Super Quad. The correct photo of the Super Quad board is shown below.





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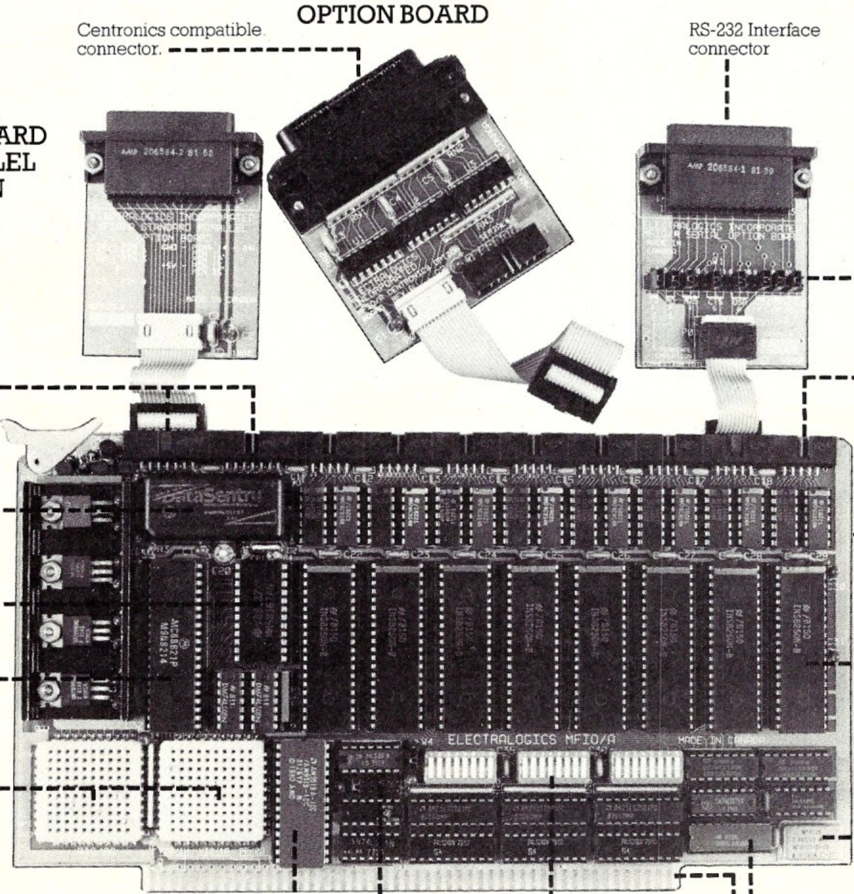
*CP/M is a trademark of DIGITAL RESEARCH, INC.



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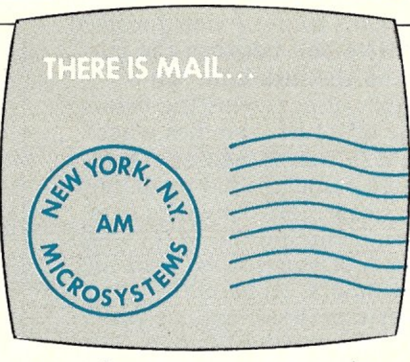

Sir,

I have just finished reading Mr. Paul H. Earley's article "Twenty-six Megabytes for Your Computer" in the November/December 1982 issue of *Microsystems*. The article was quite interesting, especially since the company I worked with used a Morrow M26 as part of a computer system to be installed in a client's offices. While I agree with Mr. Earley's comments on this Hard Disk System, there are some additional remarks regarding the M26 that I feel should be presented to your readers.

The M26 was attached to an IEEE-696 S-100 based multiprocessor microcomputer using dual 8" floppies with a Tarbell controller. The computer system was configured from its assembly to use the M26 and was in use for a period of approximately 4½ months. During this time I found the M26 to be generally reliable, with certain reservations.

One of the first things I noticed about the M26 was, as Mr. Earley stated, its "no-frills" design. This also extended to the chassis and cover. Despite the rather large size of the unit, it has no supports for the cover other than the sides. As a result, the cover has little solid structural strength and cannot safely support another unit on top of itself. Further, it is too heavy to sit directly on top of anything other than a table (assuming it is a table-top model, as was ours and apparently that of Mr. Earley). While we were able to place the computer chassis on top of the floppy disk unit, the M26 could only be used to hold manuals, forms, and other relatively lightweight items. Considering the area covered by the M26, this was a distinct disadvantage.

The noise from the cooling fan, which Mr. Earley described "as being quite loud" is very loud. This would be annoying enough by itself but when combined with the noise from the fans in the computer and the floppy disk unit, it becomes almost unbearable for any extended period of time. The client who was to receive the system decided it would have to be installed in a back storeroom rather than one of the offices due to this noise.

The documentation and software provided for installation were in my opinion far less satisfactory than Mr. Earley de-

scribes. I assume that much of this is due to Mr. Earley's previous knowledge of CPM. Our experience showed that a good working knowledge of CP/M was essential before starting the installation, and even with this knowledge a good bit of trial-and-error work was required. This is not a job for a beginner, nor is it something someone with a low frustration point should attempt.

The one major problem encountered with the M26 from a hardware point of view involved the drive belt between the motor and the disk unit. On a number of occasions the belt came off of the spindles when the M26 was turned on. Our limited resources led us to decide to turn off the entire computer, including the M26, when it was not going to be used for a few hours. Apparently the power-ups (less than one per day) overstressed the belt. The belt came off on an average of more than once every two weeks and required 20 to 30 minutes to correct. This fairly large amount of time was needed because three or more tries were usually necessary before the belt would stay in place. On one occasion the belt broke completely and had to be replaced. Morrow was helpful in this situation, and the replacement belt arrived in three days at a cost (including shipping) of approximately $31. It appeared that the motor of the M26 simply accelerated too quicly for the disk to follow.

Overall, the Morrow M26 and its cousins, the M20 and M10 hard disks, are very useful additions to any computer system. It is not, however an installation that should be undertaken by a novice, given the type of documentation and software provided with the unit. The hardware itself, although solid and basically well designed, has some problems that can cause trouble. Anyone considering acquiring a hard disk such as any of these should take these problems into account along with the comments and considerations put forward in Mr. Earley's article.

David H. Ternes
695 Kennedy Drive
Bloomfield, IN 47424

Sirs:

Microsystems has done many nice things for me in the two or so years it's been arriving in my mail, but your publication of Digital Research's CP/M patches (Jul/Aug '82) really got me going!

In addition to their intrinsic value for improving CP/M, they're a great tutorial. Someone at DR went to considerable bother—a characteristic that I didn't know DR possessed—to demonstrate several approaches to patching. Easily the best tutorial on DDT I've seen. And I've read all the books.

Working through the exercises in your tutorial has doubled the number of articles about CP/M that I understand!

Bruce W. Armstrong, M.D.
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The CP/M Bus

by Anthony Skjellum

This column is planned as a CP/M forum. Readers are encouraged to send in questions about CP/M, which I will try to answer.

Macros and Macros Assemblers: Part II

Macro instructions are a convenient facility provided by sophisticated assemblers. An introduction to macros was presented in the "CP/M Bus," *Microsystems* Nov/Dec '82. Readers should refer to this article.

REPT . . . ENDM revisited

In the previous installment on macros, an example using the REPT . . . ENDM macro sequence to produce a 7-byte area filled with zeros was in error. This is the correct form of the example:

```
AREA:   REPT    7
        DB      0
        ENDM
```

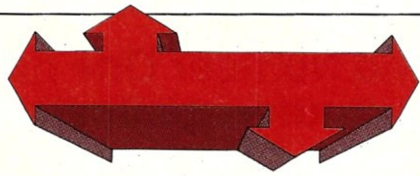
The symbol VALUE used in the original example is not needed.

Use of comments in macros

Normally, assembly language comments are delimited with the semicolon (';') character. Macros may also have comments within their definitions. However, the comments will be stored within the symbol table and added into the assembly language output at each macro expansion. This is usually not required and can also consume significant space in the assembler's symbol table. To avoid this overhead, assemblers such as Digital Research's MAC interpret a double semicolon, or fat semicolon (';;') as a special macro comment. Such comments are not stored in the symbol table and will not appear in macro expansions.

Redefining stored macros

It is often desirable to have a stored macro behave specially



on its initial invocation. This permits various initializations to be done. A macro may be redefined by placing a stored macro definition of the same name within the original definition. A simple example follows:

```
CPHLDE  MACRO               ;; compare hl to de
        JMP     @@SKIP      ;; skip the suhroutine
                            ;; which follows:
@@CP:   STA     @@ACC       ;; save accumulator
        MOV     A,L
        CMP     E           ;; compare low orders
        JNZ     @@CPEX      ;; no compare
        MOV     A,H
        SBB     D           ;; compare high orders
                            ;; setting flags
@@CPEX: LDA     @@ACC       ;; recover accumulator
        RET                 ;; and exit.
@@ACC:  DB      0           ;; data area.
@@SKIP:                     ;; where to jump to.
        ;;
        ;; redefinition:
        ;;
CPHLDE  MACRO               ;; redefine for subsequent
                            ;; calls
        CALL    @@CP .      ;; this is all required
        ENDM                ;; end redefinition
        ;;
        CPHLDE              ;; first invocation
                            ;; requires an expansion
        ENDM                ;; end macro
```

The above example compares the DE and HL register pairs and sets the 8080 register flags accordingly. On the first invocation, the subroutine @@CP: is assembled. This subroutine is preceded by a jump so that the main body of code (which called CPHLDE) skips the subroutine. After the subroutine is assembled, a redefinition macro is encountered. This redefinition changes CPHLDE to be a simple subroutine call to the @@CP subroutine just assembled. Finally, an actual compare request is generated by calling the newly defined form of CPHLDE. This is included so that a comparison of HL and DE will occur as a result of the first macro call. In order to clarify the above macro and comments, the code caused by the initial use of CPHLDE is shown here:

```
        JMP     @@SKIP
@@CP:   STA     @@ACC
        MOV     A,L
        CMP     E
        JNZ     @@CPEX
        MOV     A,H
        SBB     D
@@CPEX: LDA     @@ACC
        RET
@@ACC:  DB      0
@@SKIP:
        CALL    @@CP
```

Subsequent uses of CPHLDE cause just the last line of the macro to be assembled.

A note on LOCALs

In the previous installment, an example was included ('CMP16') to illustrate the use of LOCAL symbols. In the above macro, all but one symbol can be local. The @@CP symbol cannot be since it will be referenced by subsequent invocations of the redefined form of CPHLDE. None of the symbols have to be local since the subroutine @@CP: is assembled only once. Use of locals would be a matter of programming caution used to help avoid collision of symbol names with other programs segments. To give the macro the preferred form, the following would be added as the second line of the macro:

```
LOCAL @@SKIP,@@CPEX,@@ACC
```

which would make the symbols @@SKIP, @@CPEX, and @@ACC local and prevent potential problems.

Nested definitions

Above we discussed the possibility of redefining a macro within itself. It is also possible to define other macros within the body of a macro definition. Note that the macros specified in this way are not known to the assembler until the section of the enclosing macro which defines them is expanded. For example, consider a case where console input is to be performed via a macro called CONI. An assembly-time flag called INPFLG determines which type of BDOS input will be used. This check could be done at each invocation of the input macro, but conditional macro definition will result in faster assembly since the check is done only once.

```
INPFLG  EQU     ...         ;; depends on choice
ENTRY   EQU     5           ;; std. CP/M
        ...
DEFINE  MACRO   ;; macro define creates CONI
        IF      NOT INPFLG ;; use bdos fn 6
CONI    MACRO
        LOCAL   CJP
CJP:    MVI     E,0FFH      ;; request input
        MVI     C,6         ;; bdos direct i/o
        CALL    ENTRY       ;; execute call
        ORA     A           ;; received char?
        JZ      CJP         ;; no...
        ENDM                ;; end first choice def.
        ELSE
CONI    MACRO
        MVI     C,1         ;; bdos console read
        CALL    ENTRY       ;; execute call
        ENDM                ;; end second choice def.
        ENDIF               ;; end conditional expr.
        ENDM                ;; end def of DEFINE
```

The macro DEFINE would need to be invoked before the macro CONI could be used.

Redefinition and conditional macro definition may also be combined to have a macro redefine itself in more than one way depending on the value of a given symbol. For example, we could rename the above macro DEFINE as CONI and thus combine conditional definition with redefinition. This would also require an explicit CONI request after the redefinition so that console input would occur on the first use. The above macro would now have the following form:

```
CONI    MACRO
        IF      NOT INPFLG
CONI    MACRO
        LOCAL   CJP
CJP:    MVI     E,0FFH
        MVI     C,6
        CALL    ENTRY
        ORA     A
        JZ      CJP
        ENDM
        ELSE
CONI    MACRO
        MVI     C,1
        CALL    ENTRY
        ENDM
        ENDIF
        CONI    ;; request input
                ;; for first invocation
        ENDM
```

Careful use of the above techniques can be used to produce versatile macro libraries.

Announcing errors

As soon as macros take parameters, the possibility of erroneous parameters must be considered. The following technique is used to announce such errors:

```
 ...      ;; somewhere in a macro
 IF cond ;; some condition met
 'ERROR -- name of macro -- bad input'
 EXITM
 ENDIF
 ...
```

The assembler will flag the quoted string as an illegal operation and hence print it. This will alert the programmer to the situation. The EXITM statement is included to prevent the further expansion of the macro in which the error was discovered.

The MACLIB statement

Once a collection of macros has been created and debugged, it is convenient to place them in a single library file for reference by future programs. This is facilitated by the MACLIB statement. More than one MACLIB may be used in a program, and

THE CP/M BUS
continued . . .

these requests are normally placed near the beginning of the module. MACLIB is called as follows:

```
MACLIB LIBRARY
```

where LIBRARY.LIB is a file on the currently logged-in drive. It is also possible to specify the drive in the usual CP/M convention. The MAC assembler comes with several useful libraries, some of which will be discussed in future columns.

MACLIB may not be used to include code (other than in macros) but can be used to include symbol definitions (EQUates and SETs). This can be immensely useful since definition libraries can be included. Such libraries can include symbolic names for the BDOS function numbers and symbolic names for special addresses within the CP/M memory map. This helps to standardize usages of symbol names and also to eliminate unnecessary bugs arising from typographical errors involving special constants.

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Parameter evaluation

When evaluating a parameter, the assembler ignores any leading and trailing blanks and tab characters. The parameter must be enclosed in a single set of angle brackets if spaces and tabs are to be included as part of a parameter. (A single set of balanced angle brackets will be removed before the parameter is passed.)

Also, quoted strings are left untouched except for a single level of substitution involving the ampersand operator discussed previously. A numeric evaluation and escape character are also provided. These will be discussed in the next section.

For a summary of parameter alterations effected by the MAC assembler, see Mac Macro Assembler: Language Manual and Applications Guide, page 64.

Numeric evaluator

When a symbol is passed to a macro, it is the symbol's ASCII name, not its numeric value, which is given to the macro. If

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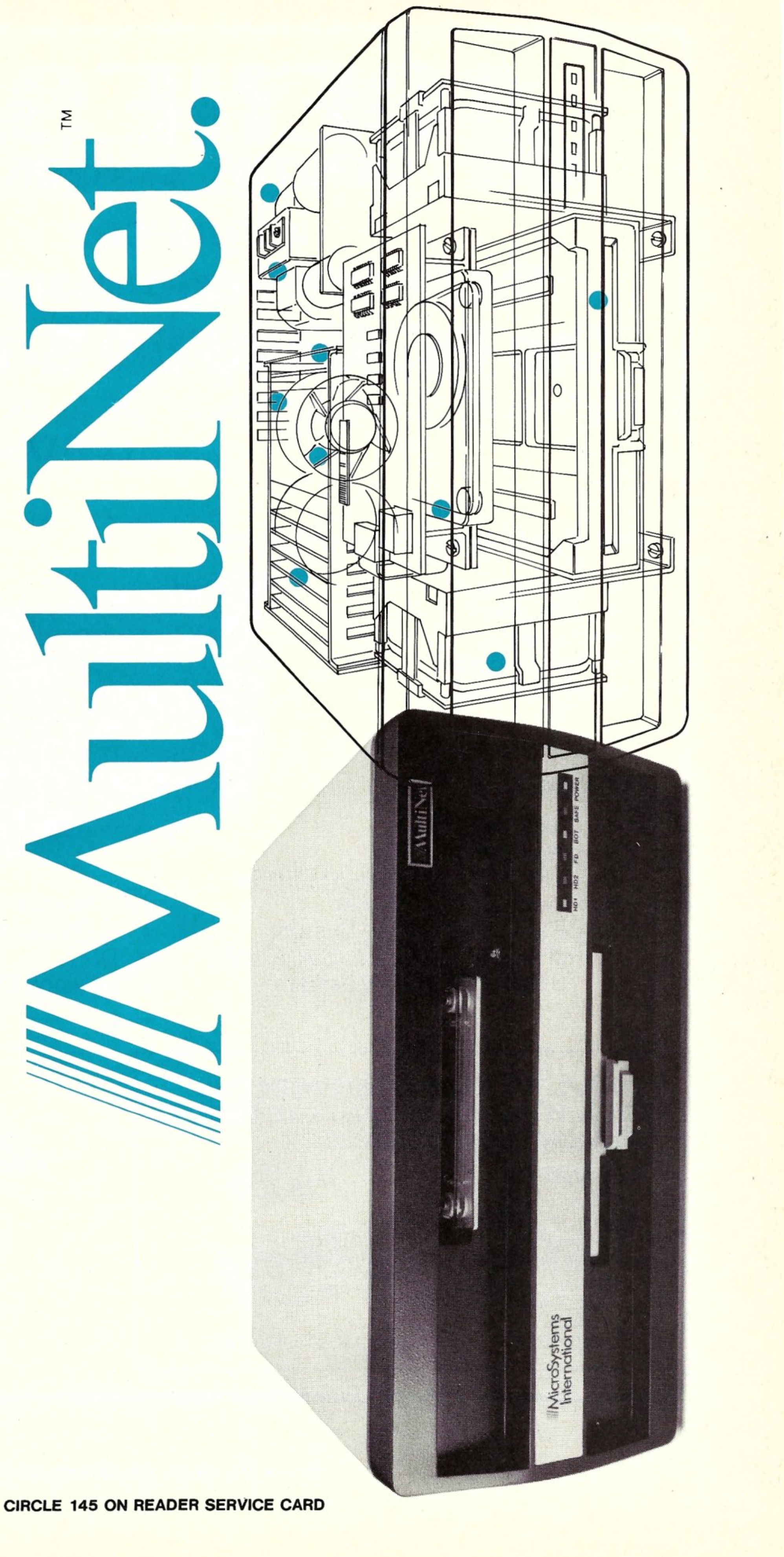

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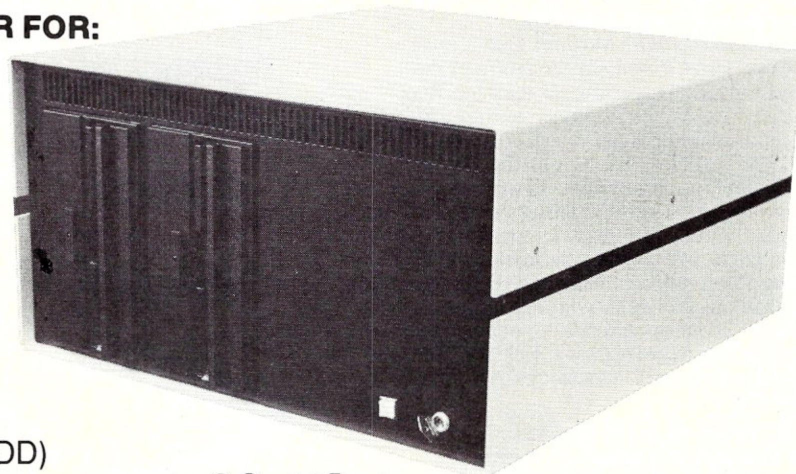

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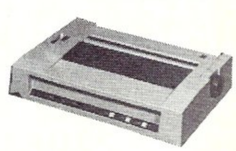

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the value of the symbol, rather than its name, is required, the percent ('%') character must precede the symbol name. Numeric expressions involving the values of symbols may also be used. For example, imagine a macro EXAMPL which requires a symbol's name and its value plus three. Such information would be passed as follows:

```
EXAMPL   SYMBL,%SYMBL+3
```

The first parameter will be the string SYMBL, while the second will be the ASCII string representing the numeric expression. Thus if SYMBL had the value 15 (assigned previously with SET or EQU), the second parameter would be the ASCII string 18.

Escape character

The escape character is a caret or up-arrow: ('^') and is used to prevent evaluation of dummy parameters within the body of a macro. This is done by a caret preceding the parameter. The caret can also be used to

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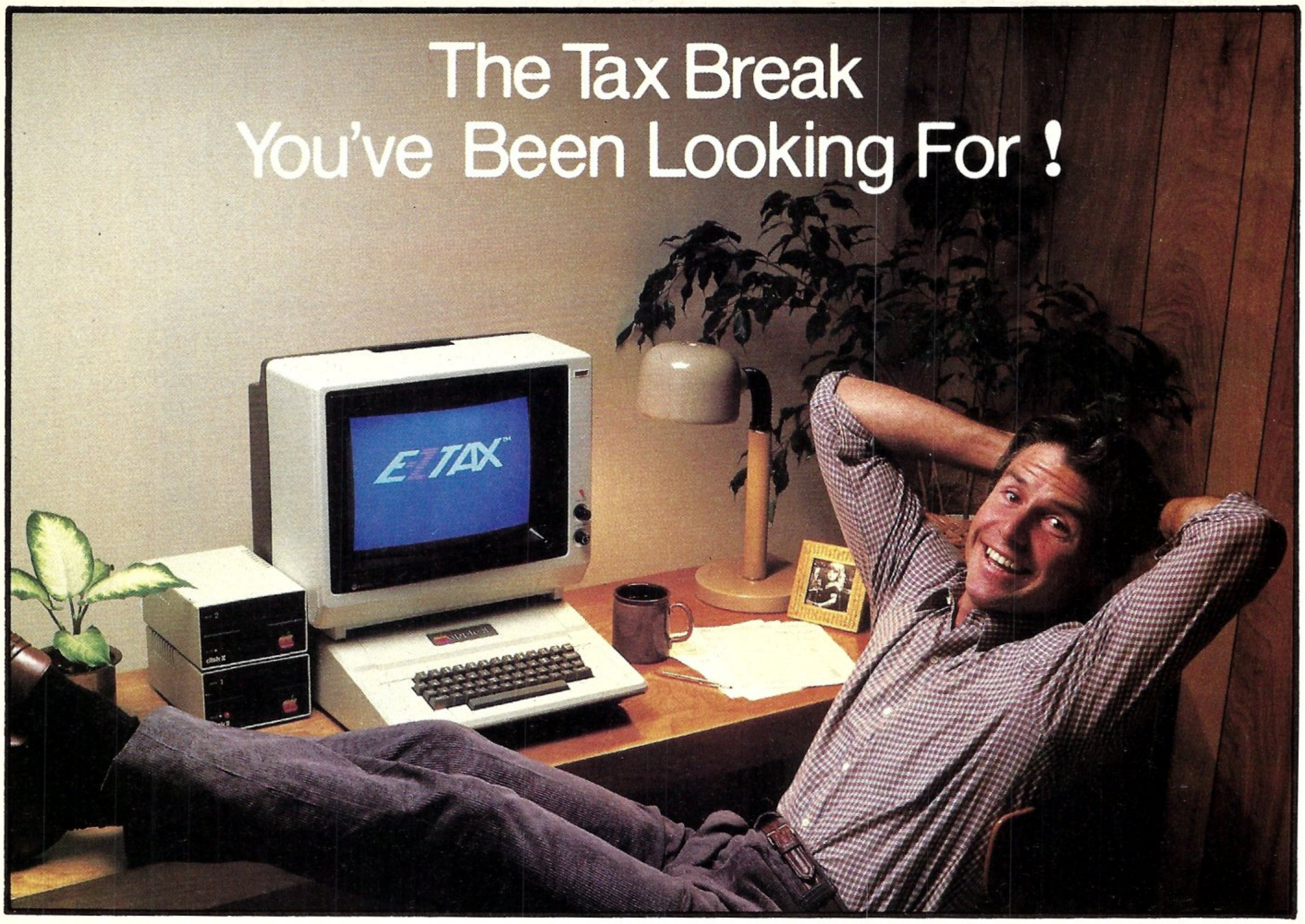

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force the assembler to treat other special characters (e.g. ';') literally within parameters. Note that the character must still be a printable ASCII character and that a literal caret is represented by a pair of carets ('^^'). Note also that the up-arrow performs no special function within the confines of a quoted string.

Conclusion

In this installment of "CP/M Bus," we have discussed more about the use of macro instruction sequences. More information about macros will be given in future installments of this column.

Coming next month:

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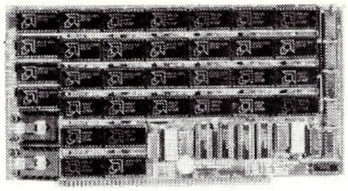

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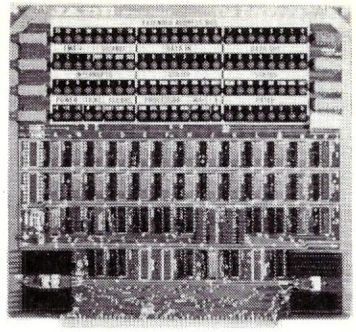

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In the Public Domain

by Chris Terry

This month I will be summarizing the high-level language processors that are available in the CPMUG and SIG/M libraries. Assemblers, cross-assemblers and related utilities will be discussed in a future column.

BASIC

Six different versions of Basic, ranging from "tiny" to elaborate are available in the CPMUG. Volume 11 contains TINIDISK, a version of the Wang Palo Alto Basic originally described in *Dr. Dobb's Journal.* The ASM source code for the interpreter is provided, together with a .COM file and a .DOC file containing full instructions for use. This was designed in the days when an 8K memory board could set you back $400 or so; the interpreter occupies only 3K and is consequently somewhat limited. But, believe it or not, TINIDISK is accompanied by a version of Star Trek (6K) which can be run with TINIDISK!

At a slightly more elaborate level is Processor Technology's BASIC/5 interpreter. The original cassette version occupied 5K; this adaptation to run under CP/M 1.3 occupies 8K. Again, a somewhat limited interpreter without transcendental functions or any form of sub-string handling. I ran the original cassette version and found it adequate for simple games (such as those in David Ahl's "101 Games for Computers"); I have never given this CP/M version anything of a workout, though I was able to bring it up under CP/M 1.4 and run one of the guessing games.

Volumes 31 and 32 of CPMUG contain the source code, documentation and executable module of an early version of Tarbell Basic. This needs a lot of experimentation. I tried to run version 12.1 (much later than this public domain version) and found the editor infuriating and difficult to work with, and there were still some bugs. In its day this was a very advanced interpreter with WHILE . . . WEND and other structures absent even from Microsoft's Version 4, but I found the editor so tricky that I gave up on it—other people tell me they had better luck.

Probably the two most useful versions are the Lawrence Livermore interpreter in Volumes 2 and 10 of CPMUG, and EBASIC, included in Volume 26 of the SIG/M library. EBASIC is a semicompiler with a runtime interpreter, and is the ancestor of CBASIC, CBASIC2 and CB-80. This is more powerful than the other public domain Basics, in that it has higher precision, requires no line numbers except in statements that are the targets of GOTOs or GOSUBs, and has better control structures. However, it is somewhat slow and is less convenient than an interpreter when it comes to debugging. EBASIC was supplied free with CP/M by various disc controller manufacturers, and the manual is still available from various sources. An EBASIC Help file is available on SIG/M Vol. 14 (requires HELP.COM in Vol. 13 to run it); this gives you on-line help relating to EBASIC procedures, error messages, etc. SIG/M Vol. 26 was also published (without change) as CPMUG Vol. 53. Floating Point conversion routines for EBASIC appear in Vols. 29 & 30, together with the PL/M source of the compiler and runtime interpreter.

Other procedure-oriented languages

FOCAL, a language similar to Basic supplied by Digital Equipment Corp. for use on their PDP/8 and other machines, was adapted to run under CP/M and issued in CPMUG Vol. 16. ALGOL/M, a subset of Algol-60, is available with full documentation and a useful set of test and demonstration programs in Algol/M on CPMUG Vol. 28.

RATFOR (the acronym stands for RATional FORtran) is a preprocessor for Fortran source programs. It allows control structures such as IF . . . ELSE, WHILE, REPEAT UNTIL, FOR . . . NEXT, BREAK, and INCLUDE, and generates standard Fortran statements. A .COM file of the preprocessor is contained in CPMUG Vol. 24; a faster version for Z80 only is in CPMUG Vol. 49, together with the RATFOR source, documentation, and some demonstration programs. The output of the RATFOR preprocessor can be compiled with the Microsoft Fortran-80 compiler.

A Pascal compiler (written in Pascal) is available in SIG/M Vol. 50. This differs somewhat from standard Pascal, but the differences are fully documented. A preprocessor makes a single pass over the source code, generating a sort of p-code which is written to disk. A two-pass translator then scans the p-code and generates 8080 object code which is linked to a runtime library by using PIP.

Threaded languages

Two languages of this type are available in the public domain: FORTH11 (SIG/M 13, republished as CPMUG 65) and STOIC (CPMUG 23 & 25). Both of these languages use Reverse Polish Notation and a threaded block structure that allows you to define your own

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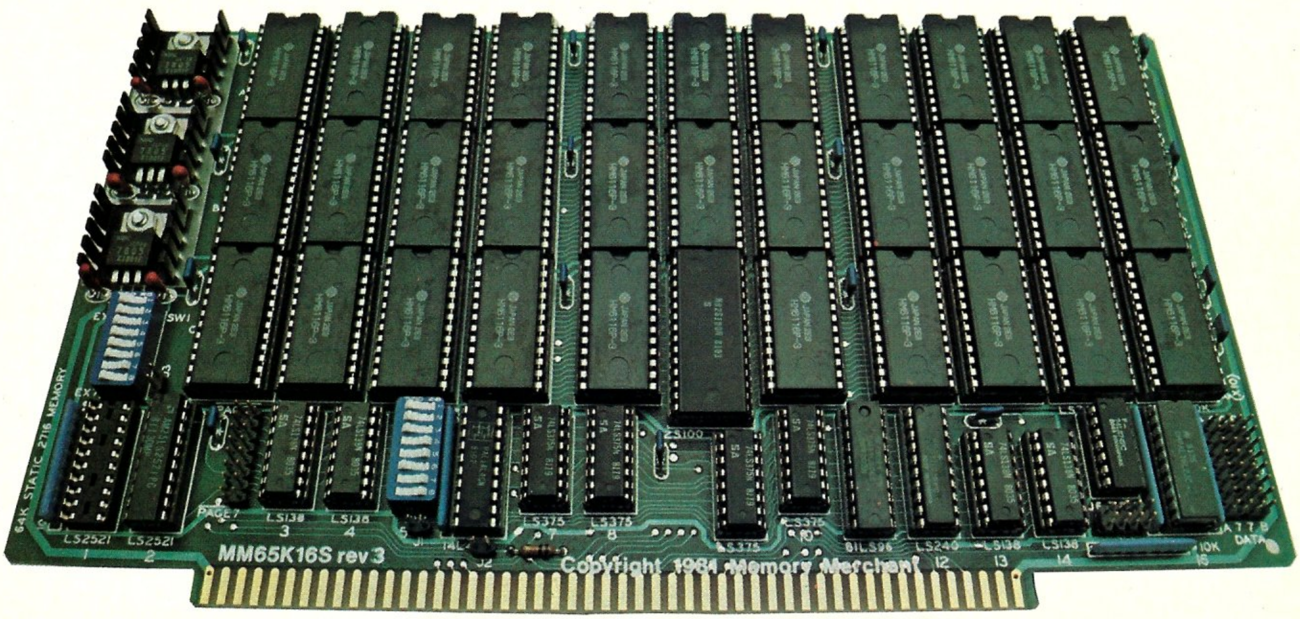

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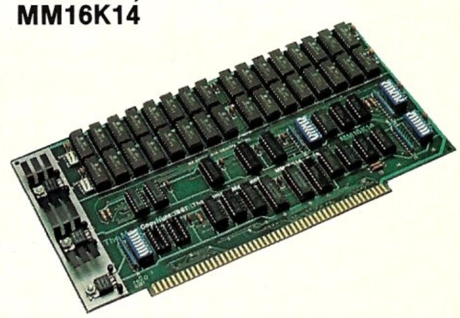

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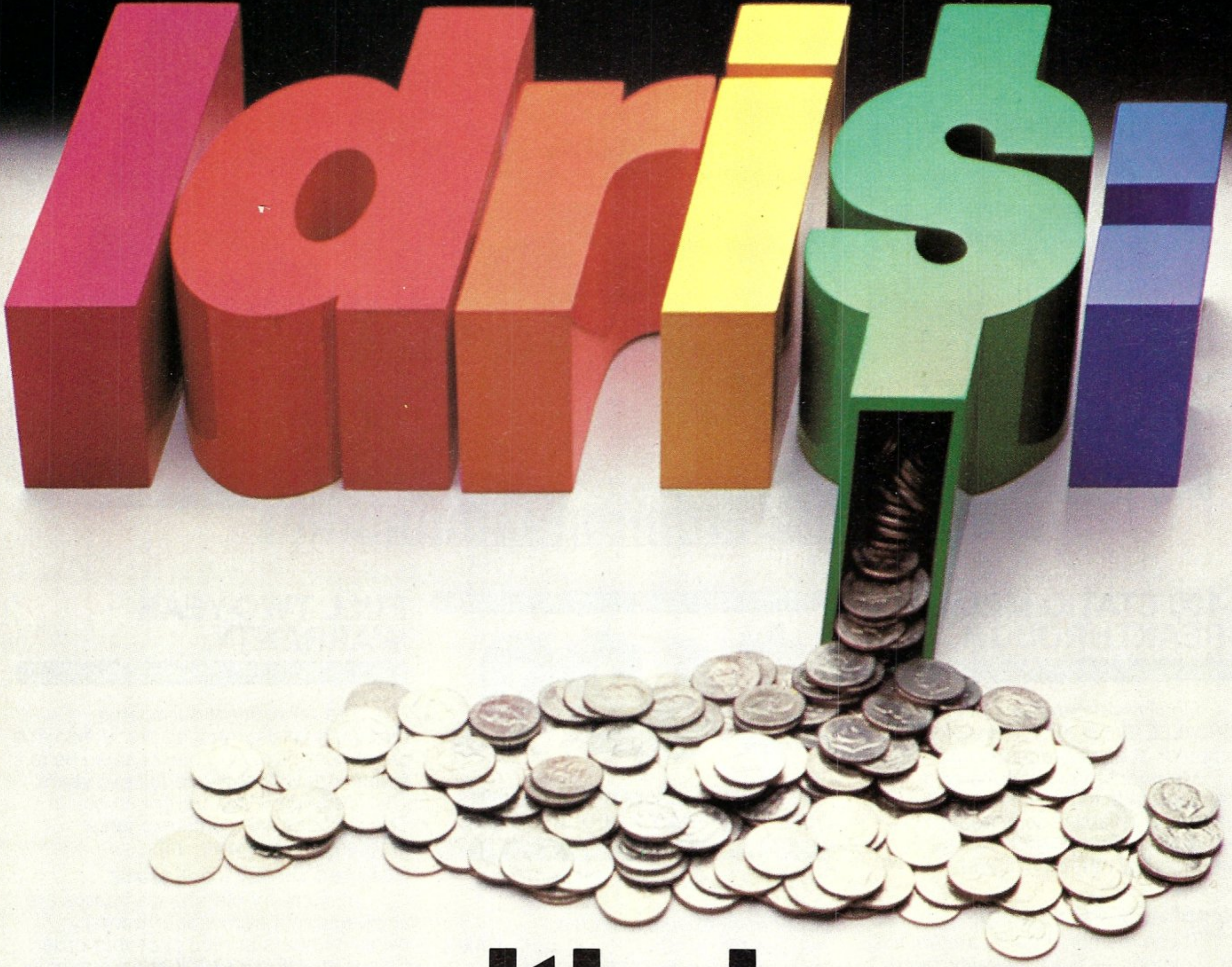

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extensions to the language. Both are interactive, which makes for easy debugging, but generate fast, compact machine language code in the manner of a compiler. FORTH11 is in fact Fig-Forth Version 1.1 and ran under the contributor's CP/M 1.43. He emphasizes that you should obtain the Fig model manual and the Fig Assembly Source Listing before attempting to use the program, in case any modifications are needed. STOIC is rather similar to Forth, but may produce more compact code in some applications (see Richard Mossip's article "Stoic versus Forth" in the Sep/Oct 1982 issue of *Microsystems.*)

PISTOL (Portably Implemented Stack Oriented Language, SIG/M Vol. 59) was inspired by and has evolved from Forth and Stoic. Like these, Pistol uses RPN. At present all arithmetic is performed in integer form. The author notes that this language is still "in an early developmental stage," and it may therefore have bugs. The CP/M implementation was written in C and compiled with the BDS C compiler.

Other languages

ACTOR (CPMUG Vol. 4.) is a TRAC-like string-processing language that comes with a comprehensive manual and some sample programs.

PILOT (Programmed Inquiry and Learning) is an interactive language for use in computer-aided instruction, where easy pattern-matching of responses is required. The complete documentation and listing were published in *Dr. Dobb's Journal*, April and May 1977. The version in CPMUG Vol. 7 is for an Intel MDS but can be processed by ASM except for one statement that contains an 8-bit negative value (ASM insists that negative values have 16 bits). CPMUG Vol. 12 contains source code patched to interface properly with CP/M.

CASUAL (CPMUG Vol. 18) is a language originally described in *Dr. Dobb's Journal* for December 1976. This version has no CP/M I/O, but has standard Intel mnemonics (which the original did not).

SAM76 (CPMUG Vol. 34) is a macro and string processing language that is powerful and, to some degree, extensible. It has been very successfully used in controlling a mobile robot, but has many other possibilities if you can master its subtleties.

PIDGIN, TINCMP (SIG/M Vol. 43). Pidgin is a systems programming language described in the July 1981 issue of *Dr. Dobb's Journal*. TINCMP is a compiler for special purposes, written in Pidgin. The volume contains documentation on how to use Pidgin and how to put together a TINCMP compiler for your own special purpose; all macros and utilities needed are supplied on the disk.

An IEEE-488 Bus Tutorial

by Richard S. Newrock

One of the most important uses of computers is to control industrial processes and laboratory experiments. To accomplish this it is often necessary to connect the computer to a variety of test and measurement equipment. This article describes the industry standard for interfacing computers to programmable instruments, a standard commonly known as the "488 bus" (IEEE-488/1978) or the "GPIB" (General Purpose Instrument Bus). The bus is known by other names as well, two of which are the "HPIB" (Hewlett-Packard Interface Bus) and the "ASCII bus."

The 488 bus is the first universal computer/instrument interface and is probably the most well designed and consistent of all computer interfaces. The bus has become a worldwide standard primarily because of its ease of use, its well-defined functions, and its well-thought-out handshaking protocol. It is used by more than 175 manufacturers of nearly 1,500 instruments. Most of these are measurement and test instruments, but printers and plotters are also available. A user can select instruments from different manufacturers and be certain that (electronically) they will work together perfectly. No custom interface design will be needed. In addition, all commands and data are coded in ASCII (hence the "ASCII bus"), making bus operation and control particularly simple. So simple, in fact, that bus control can be done with programmable calculators; a computer is not a necessity. With a good software package even a novice can quickly design and construct a very complicated instrumentation system.

State-of-the-art instrument and computer manufacturers always try to use the latest and fastest technology. This resulted in the creation of a wide variety of computer/instrument interfaces during the '60s and early '70s. Unfortunately, most of these were incompatible. Steve Leibson[1] has described the situation as similiar to that which existed in railroading during the 1850s and '60s: each railroad used a different track gauge, and interfacing (passing a train of freight cars from one line to another) was impossible. A more modern illustration is the different buses currently used in microcomputers.

During the mid-'60s the Hewlett-Packard Corporation decided it needed a standard computer/calculator interface for all its future instruments. Their design was taken by the International Electrotechnical Commission (IEC) as a starting point for an industry-standard interface. By 1974 a draft of the standard was ready for approval. Shortly thereafter, the Institute of Electronics and Electrical Engineers (IEEE) presented a draft for their own standard, the IEEE-488/1975. These were soon adopted and were followed by the essentially similar American National Standards Institute (ANSI) standard in 1976. The three "standards" are the IEE-488/1978[2], the IEC-625-1[3], and the ANSI-MC1.1[4]. The IEEE standard was revised in 1978 for a variety of reasons. Most important, it was necessary to clarify some of the language and reflect new technology—in particular, Schottky logic. The result, IEEE-488/1978, is the standard of interest to us.

Before describing the "488" standard and its implementation, it is worth making a small digression. Exactly what is a meant by a "standard"? What should it specify and what should it *not* specify? How much detail is to be given? A standard is a detailed specification of the important mechanical, electrical, and functional aspects of a device or a system. It must fix as many of the important parameters as possible without hindering the device's applicability or flexibility. If possible, it should not deal with the actual electronic design of the device; if it does, it will make the use of new technology more difficult. It ought to detail the function of the device without forcing the manufacturer into using a particular design or circuit.

The IEEE-488 interface standard addresses all of these concerns. It specifies only those electrical and mechanical parameters of the bus which are necessary to ensure compatibility: the cable, the connectors, the voltage levels, and the current drain. It does not intrude where it is not needed (for example, the circuit design and layout of the interface). It defines a number of bus commands and functions, but does not tell how, or indeed if, they are to be used.

The 488 standard defines the instrument bus, its functions, and the instrument interfaces. It defines the handshaking, the bus commands and the data transfer technique. A schematic of the bus is shown in Figure 1, where the bus, several instruments, and the controller are indicated. The bus is nothing more than a cable, with appropriate connectors daisy-chained to the various devices. Each device (including the controller) connected to the bus consists of two parts: an instrument-independent portion, the interface, defined by the standard, and an instrument-dependent portion, defined by the manufacturer. Only the instrument interface "talks" to the bus; commands and data coming over the bus may be interpreted by the instrument, but are sent and received by the interface. Perhaps the best way to describe these interfaces is that they allow the controller to operate the instrument in place of the instrument's front panel. That is, the interface allows the controller to program the instrument in exactly the same way that a person would from the front panel. Because of this the 488 bus is sometimes called the "interface bus."

An instrument system consists of devices that can play one or more of three different roles: controller, talker, or listener. All devices must act in at least one of these assigned roles; they provide

Richard S. Newrock, Dept. of Physics, Univ. of Cincinnati, Cincinnati, OH 45221

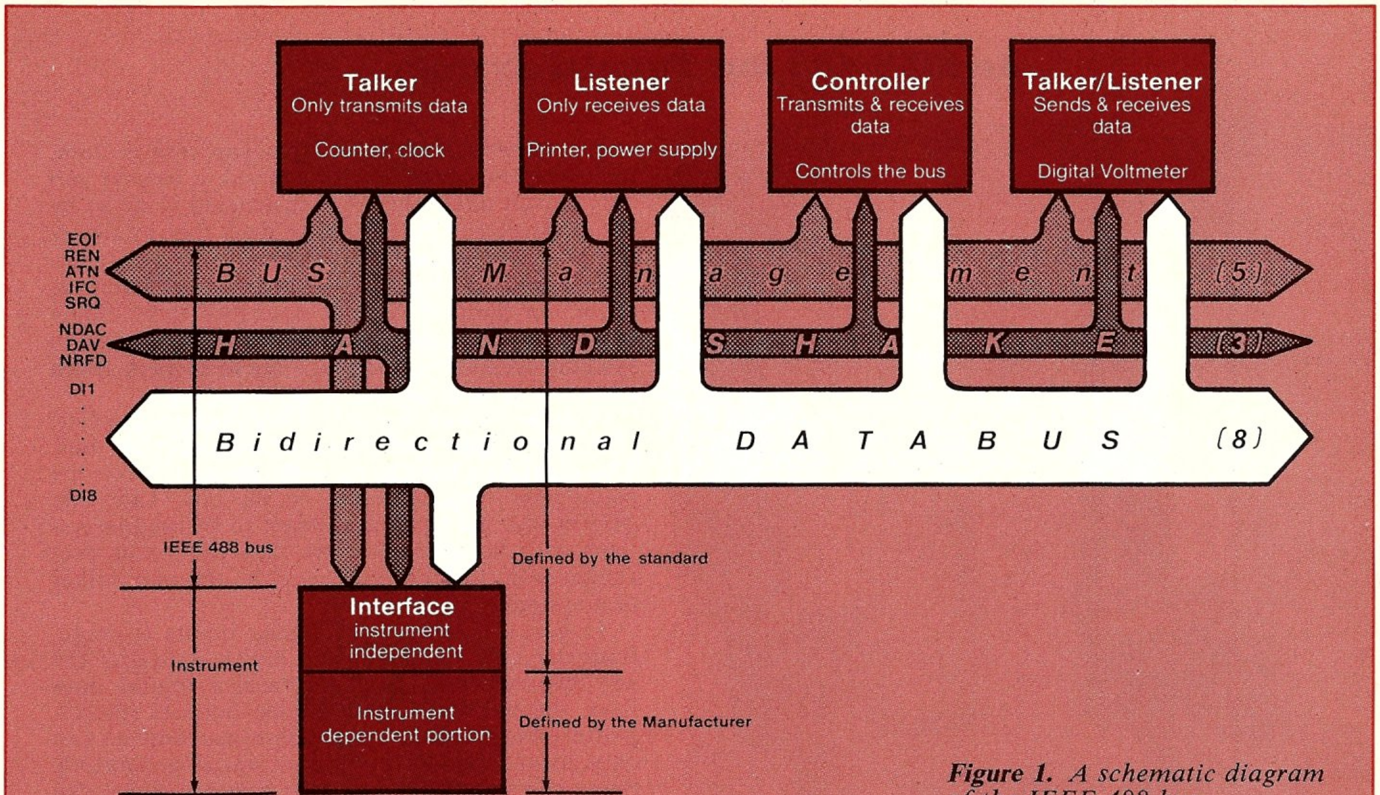

Figure 1. *A schematic diagram of the IEEE-488 bus.*

the basis for the flow of information over the bus. The controller is a device that can manage the bus, including sending bus commands, and instructing other devices when to transmit (become talkers) or receive (become listeners). This is clearly the role played by the computer. Every device on the bus (including the controller) must follow strict rules assigned to its role. These rules allow orderly operation and data transfer.

The data transfer rates of the various instruments are not overly important; in fact this is one of the unique features of the bus. The handshaking has been designed so that the data transfer rate depends on the speed of the transmitters and receivers and not on a fixed system clock. The ultimate transfer rate is determined by the slowest active instrument on the bus. Thus, a wide variety of instruments can operate together, even if they have very different transfer rates and operating speeds. The communication is completely asynchronous, and it can even be interrupted during the handshake without loss of data.

The standard

The electrical, mechanical, and functional aspects of the bus are described in detail in this section. We begin with the mechanical and electrical specifications, since these are simple and straightforward.

The bus consists of a 24-conductor cable connected to the instruments with ribbon connectors (IEEE-488/1978 and ANSI-MC1.1). Each end of the cable has both male and female connectors, allowing the cables to be stacked (Figure 2). That is, several cables can be connected to a single point without using "Y's" or "T's". Unfortunately, the IEC-625.1 standard specifies a type-D connector, a DB-25. Use of this connector should be avoided, as it is the same connector used for RS-232 serial ports. RS-232 voltage levels differ substantially from 488 voltage levels, and a misconnection will severely damage the 488 interface. Adapters are available to convert to ribbon connectors; these should be placed on the instrument and left there. There is another problem about which one should be aware. Most instruments use connectors with metric threads (black screws). However, English threads are occassionally used (silver screws); be careful not to mix them up or the threads will be destroyed.

The instruments and the controller can be connected in any order; they are just "device loads" to the bus. As many as 15 devices, including the controller, can be used. They can be connected linearly (daisy-chained), in a "star" (radiating outward from a point), or in any combination of the two. The only limitation is that there be no more than 2 meters of cable per device, up to 20 meters maximum (unless a bus extender is used). This is because the interface electronics must maintain the proper voltage levels and timing and, if the cable is too long, the interface cannot drive the lines. The devices need not be evenly spaced on the cable, but should be no more than 4 meters apart.

The 488 bus uses negative true logic, opposite to that used on the S-100 bus. Zero, or false, is a voltage greater than 2.0V and 1, or true, is 0.8V or less. All lines on the bus are active low (true) and

The 488 bus has become a worldwide standard primarily because of its ease of use, its well-defined functions, and its well-thought-out handshaking protocol.

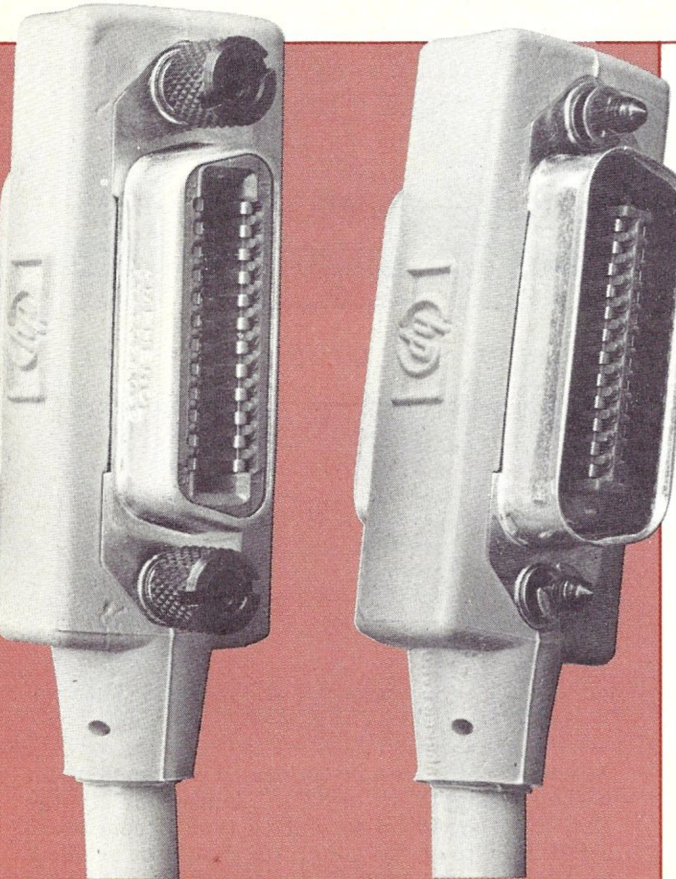

Figure 2. Typical 488 bus cabling and connectors. Note that the cables have male and female connectors on each end. This allows them to be "stacked." The cable has 24 conductors, in 12 twisted pairs, each pair being individually shielded. There is also a common shield around the whole cable. (Photo by J. Helton.)

are pulled passive high (false) at each instrument. Of the 24 bus lines, 8 are grounds, 8 are for data, 5 are for bus management, and 3 are for handshaking. (See Figure 3 for the pin assignments.) Three of the lines, SRQ, NRFD, and NDAC (all defined below) must have open collector drivers. For these three lines, if one or more of the instrument drivers are on, the line will go low. This is a "wired-or" configuration, and it is very important for the handshaking. The rest of the lines can have either tristate or open collector drivers. However, if the instrument supports parallel polls (a way to check if an instrument needs service), the data lines must be open collector as well.

The definitions of the various bus functions are among the most important parts of the standard. They define the roles of the instruments, what the interfaces can do, and the commands they may obey. We begin with the three roles defined for each instrument: listener, talker, and controller.

A *listener* is any device that can receive data, including the controller. In general, a listener can only accept data when it is instructed to do so by the controller. The controller does this by designating ("addressing") the device to be a listener. This is done by placing the instrument's "listen address" on the data bus, as described later. Some devices are listen-only and are meant to be used in systems with no controller. These always listen and cannot be prevented from doing so.

A *talker* is any device, including the controller, that, when addressed, can send data over the bus. The controller designates a device as a talker by placing its "talk address" on the bus. Talk-only devices also exist and are meant to be used in systems with no controller. As they cannot be prevented from talking, they must be the only talker in a system.

In general, talkers get analog inputs (voltage, frequency, etc.) and transmit digital data over the 488 bus, whereas listeners receive digital data from the bus and create analog outputs (pulses, plotter-pen position, etc.). Some instruments can only listen, e.g., printers and signal generators. Some can only talk, e.g., tape readers. Some can perform both roles; e.g., a digital voltmeter can receive programming instructions and send measurements. When a device can be both a listener and a talker, the controller determines which function is active by how it addresses the instrument.

The *controller* can not only transmit and receive data, but can issue commands; it is the only device allowed to manage the bus. The controller can designate listeners and talkers, program them, trigger them, send instrument-dependent messages and interface-dependent messages. It can conduct polls to determine instrument status and handle service request interrupts. In short, it and its programs run the system. There is a provision in the standard to have more than one controller and to pass control between them, but this is seldom done.

Functions, commands, and addressing

The standard defines a number of functions that the instrument interfaces can perform. In addition, it defines the commands that they may recognize. A command tells the instrument interface to perform one of the functions. It is important to note that every instrument does not have to perform every function or obey every command. The manufacturer determines which are necessary for the operation of his instrument.

There are 10 interface functions, each with a set of options. Of these, five may be considered basic: an instrument may be a *talker*, and if so, must be able to decode talker addresses and perform the talker (or source) handshake. The *source hand-*

Bus control is so simple it can be done with programmable calculators. With a good software package, even a novice can quickly design and construct a very complicated instrumentation system.

shake is a function that allows the interface to transmit data properly. Similiary, *listeners* must decode listener addresses and perform the listener (or acceptor) handshake (the *acceptor handshake* function allows for proper reception of data), and *controllers* must be able to manage the bus. These five functions obviously determine whether an instrument can send and receive data and whether it can control the bus. These functions and the possible options are shown in Table 1. In addition to the basic functions, there are five others:

REMOTE/LOCAL. *This function determines whether an instrument responds to its front panel or to programming information on the bus.*

SERVICE REQUEST. *This function allows the instrument to request service from the controller at some point in its operation or when an error has occurred. It is used in conjunction with the "serial poll," which is described more fully later.*

PARALLEL POLL. *If this function is implemented, an instrument can identify itself to the controller when it needs service. It does this by setting or clearing a single data bit when polled. A seldom-used function, it is desribed in detail under polling.*

DEVICE CLEAR. *This function allows the controller to return a device to a manufacturer-determined default state, usually the state at power-up. This function is nearly always implemented.*

TRIGGER. *If this function is implemented, the device's function can be initiated by the controller. For example, a pulse generator can be triggered when a pulse is desired. This function is almost always implemented when the use of the instrument warrants it. It is often used to synchronize and trigger groups of instruments.*

The controller designates listeners and talkers, and issues commands to perform bus functions over the five bus management and the eight data lines. The 488 bus has two main modes of operation: command mode and data mode. The mode is determined by the attention (ATN) line, one of the five bus management lines. When ATN is true, we are in the command mode: all instruments must listen to the controller, which sends "commands" over the data lines. When ATN is false, we are in the data mode: instruments previously addressed as listeners and talkers send and receive "messages" over the data lines. When in command mode, the instrument interfaces accept and interpret the commands. In the data mode, the interface accepts or transmits the messages, but the instrument itself interprets or provides the messages.

There are two types of commands, UNILINE and MULTILINE, referring to the number of bus lines needed to transmit the command. For example, ATN has a line dedicated to its use and is therefore a uniline command. Uniline commands use the bus management lines. Multiline commands use the first seven data lines, with ATN true (to indicate command mode).

Uniline commands

ATTENTION (ATN). *ATN tells an instrument if the information on the data lines is a command or a message. When true, the byte on the data bus is interpreted as either a talk or listen address or as a universal or addressed command. ATN forces all instruments to stop what they*

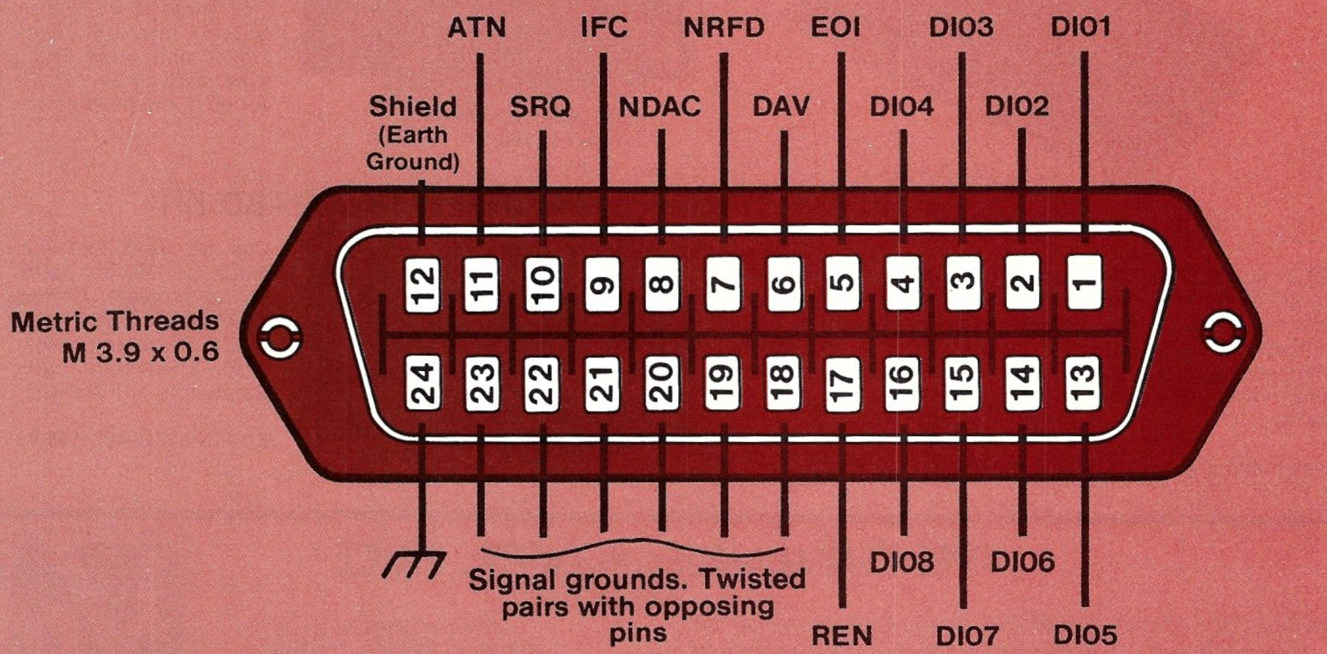

Figure 3. The pin-out of the ribbon connector used in the IEEE and the ANSI standards. This is usually an Amphenol 57-20240-2 or its equivalent.

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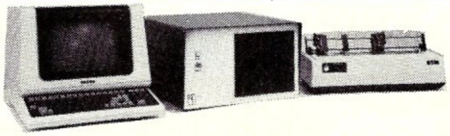

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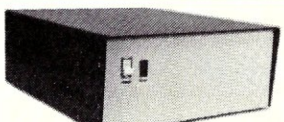

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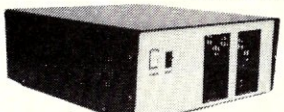

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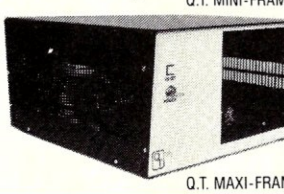

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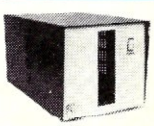
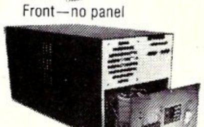


Front—Tandon Panel

Front—no panel



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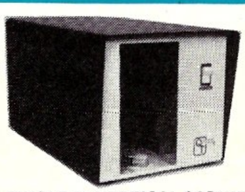

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are doing and listen to the controller; it can be asserted only by the controller.

INTERFACE CLEAR (IFC). *This line clears the bus and sets all instruments to idle. It is normally asserted at power-up and may be asserted only by the controller. IFC halts all data transmission, unaddresses all instruments, and stops all polls.*

REMOTE ENABLE (REN). *Most instruments can be programmed either by the front panel or by information on the bus. When this line is asserted the instrument responds to the bus and*

Table 1. The interface functions, their options, and the capability identification codes.

Functions					Capability ID and options				
Controller					C				
Talker					T				
Extended talker					TE				
	T0	T1	T2	T3	T4	T5	T6	T7	T8
Basic talker		x	x	x	x	x	x	x	x
Serial poll		x	x			x	x		
Talk-only mode[1]		x		x		x		x	
Unaddress if addressed to listen[2]						x	x	x	x
No capability	x								
Listener					L				
Extended listener					LE				
	L0	L1	L2	L3	L4				
Basic listener		x	x	x	x				
Listen-only mode[3]		x		x					
Unaddress if addressed to talk[2]				x	x				
No capability	x								
Source handshake					SH				
No capability	SH0								
Full capability	SH1								
Acceptor handshake					AH				
No capability	AH0								
Full capability	AH1								
Service request					SR				
No capability	SR0								
Full capability	SR1								
Remote/local					RL				
No capability	RL0								
Full capability	RL1								
No local lockout	RL2								
Parallel poll					PP				
No capability	PP0								
Remote configuration	PP1								
Local configuration	PP2								
Device clear					DC				
No capability	DC0								
Full capability	DC1								
No selected device clear	DC2								
Driver electronics					E				
Open collector	E1								
Tristate	E2								

1. Allows an instrument to transmit data without a controller on the bus.
2. Prevents an instrument from talking and listening at the same time.
3. Allows an instrument to receive data without a controller on the bus.

not to the front panel (see also LLO and GTL).

SERVICE REQUEST (SRQ). *This line can be asserted only by an instrument. It is used to signal the controller that the instrument needs service. The controller performs a '"serial poll" to determine which device has requested service and branches to a service routine. SRQ is not released by the instrument until it is polled.*

END OR IDENTIFY (EOI). *This uniline command is used in conjunction with ATN. If ATN is false, EOI is set by the talker and indicates that the last byte of a message string is being sent. The controller sets EOI and ATN to perform a parallel poll.*

Multiline commands

There are four types of multiline commands: UNIVERSAL, ADDRESSED, UNADDRESS, and ADDRESS commands. A universal command is obeyed by all instruments regardless of whether or not they have been told to listen. An addressed command is obeyed only by those devices which have been designated as listeners. The unaddress commands remove the talker and all listeners from the bus, and the address commands designate the talker and the listeners. An instrument's interface recognizes the type of command transmitted by the state of data bits 5, 6, and 7. A universal command always has lines 6 and 7 false with 5 true (001XXXX). An addressed command always has

Table 2. ASCII codes and 488 code identification

			b4	0		0		0		0		1		1		1		1	
			b6	0		0		1		1		0		0		1		1	
			b5	0		1		0		1		0		1		0		1	
b4	b3	b2	b1	ASCII	COMMAND	ASCII	COMMAND	ASCII	Primary Address	ASCII	Primary Address	ASCII	Primary Address	ASCII	Primary Address	ASCII	Secondary Address	ASCII	Secondary Address
0	0	0	0	NULL		DLE ↑P		SP	0	0	16	@	0	P	16	1	0	p	16
0	0	0	1	SOH ↑A	GTL	DC1 ↑Q	LLO	!	1	1	17	A	1	Q	17	a	1	q	17
0	0	1	0	STX ↑B		DC2 ↑R		"	2	2	18	B	2	R	18	b	2	r	18
0	0	1	1	ETX ↑C		DC3 ↑S		#	3	3	19	C	3	S	19	c	3	s	19
0	1	0	0	EOT ↑D	SDC	DC4 ↑T	DCL	$	4	4	20	D	4	T	20	d	4	t	20
0	1	0	1	ENQ ↑E	PPC	NAK ↑U	PPU	%	5	5	21	E	5	U	21	e	5	u	21
0	1	1	0	ACK ↑F		SYN ↑V		&	6	6	22	F	6	V	22	f	6	v	22
0	1	1	1	BEL ↑G		ETB ↑W		'	7	7	23	G	7	W	23	g	7	w	23
1	0	0	0	BS ↑H	GET	CAN ↑X	SPE	(	8	8	24	H	8	X	24	h	8	x	24
1	0	0	1	HT ↑I	TCT	EM ↑Y	SPD	)	9	9	25	I	9	Y	25	i	9	y	25
1	0	1	0	LF ↑J		SUB ↑Z		*	10	:	26	J	10	Z	26	j	10	z	26
1	0	1	1	VT ↑K		ESC		+	11	;	27	K	11	[	27	k	11	{	27
1	1	0	0	FF ↑L		FS		,	12	<	28	L	12	/	28	l	12	|	28
1	1	0	1	CR ↑M		GS		-	13	=	29	M	13	\	29	m	13	}	29
1	1	1	0	SO ↑N		RS		.	14	>	30	N	14	∧	30	n	14	~	30
1	1	1	1	SI ↑O		US		/	15	?	UNL	O	15	_	UNT	o	15	DEL	

Addressed Command Group — Universal Command Group — Listen Address Group — Talk Address Group — Secondary Address or Command Group

Primary Command Group

LLO = Local Lockout
DCL = Device Clear
PPU = Parallel Poll Unconfigure
SPE = Serial Poll Enable
SPD = Serial Poll Disable
GTL = Go to Local
SDC = Selected Device Clear
PPC = Parallel Poll Configure(requires secondary command)
GET = Group Execute Trigger
TCT = Take Control

5, 6, and 7 false (000XXXX). Each command is represented by an ASCII character, as displayed in Table 2. The first 16 ASCII control codes form the addressed command group, and the last 16 control codes form the universal command group. There are currently five defined universal commands and five defined addressed commands.

Universal commands

DEVICE CLEAR (DCL). *This command causes all programmable instruments to return to a default state determined by the manufacturer.*

LOCAL LOCKOUT (LLO). *This command disables the front panel local/remote button, providing security from tampering and protecting instruments from accidental return to local control. Local operation can be restored by setting REN false or by using GTL. LLO is unaffected by an interface clear (IFC).*

SERIAL POLL ENABLE (SPE). *This command places all talkers in the serial poll mode. When addressed in this mode, an instrument puts its status byte onto the data bus. The status byte, defined by the manufacturer (see polling), provides information about the instrument.*

SERIAL POLL DISABLE (SPD). *This command terminates a serial poll and returns all devices to their normal state. When addressed to talk, data rather than instrument status is placed on the data bus.*

PARALLEL POLL UNCONFIGURE (PPU). *This command resets all instruments to the "parallel-poll-idle" state.*

Addressed commands

GO TO LOCAL (GTL). *GTL returns all addressed listeners to local (front panel) control, causing them to exit the remote state. When addressed again they return to remote. GTL is useful for making operator adjustments on particular instruments without dropping all devices out of remote.*

GROUP EXECUTE TRIGGER (GET). *This command will trigger all devices addressed to listen, allowing them to initiate their functions. This permits synchronization and simultaneous triggering of all devices.*

SELECTED DEVICE CLEAR (SDC). *This command resets the addressed instrument to its default state.*

TAKE CONTROL (TCT). *TCT tells another controller to take over bus management.*

PARALLEL POLL CONFIGURE (PPC). *This command causes the addressed listener to configure its status bit according to a secondary command, which must follow (see Polling).*

Address and unaddress commands

The process of designating an instrument as a talker or a listener is called "addressing." Every talker or listener has an ASCII identification code called its address. Sometimes (most often with programmable calculators), the controller will have a talk and listen address as well. Most devices have only one address, the primary address, but some have secondary addresses or two primary addresses. When secondary addresses are present, we say the instrument is an extended talker or extended listener. In this case, the primary address designates the instrument (a digital voltmeter for example), while the secondary addresses might designate instrument functions (ohms, amps, etc.), or particular circuit cards or modules.

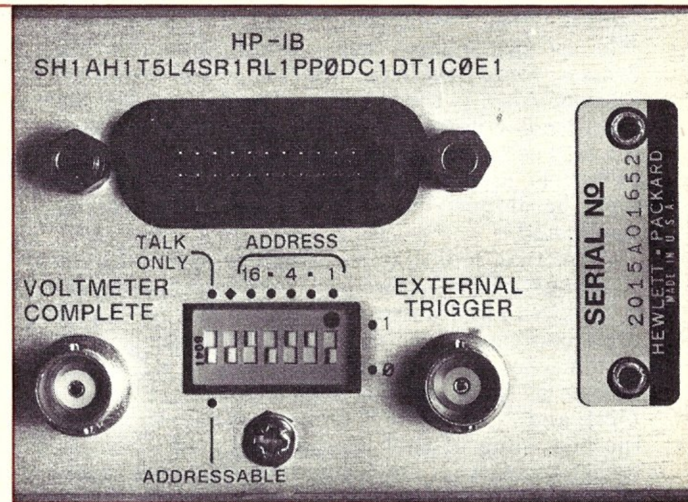

Figure 4. The back panel of a typical 488-compatible instrument, the Hewlett-Packard 3465A digital voltmeter. We see the 488 connector and the address DIP switch below it. Above the connector is the "capability ID" (see text). (Photo by J. Helton.)

The controller tells an instrument to listen or talk by putting its address code on the data lines while asserting ATN. Secondary addresses must be placed on the bus immediately following the primary address. Listen addresses have bit 6 true and 7 false (01XXXXX), while talker addresses have bit 6 false and 7 true (10XXXXX). Secondary addresses have both 6 and 7 true (11XXXXX). All 7 bits form the ASCII character that represents the address (Table 2) and the address can be referred to by that character or by the decimal number formed by the lower five bits.

Most instruments have a five-pole dipswitch on the back panel (Figure 4) that is used to set its address (the switch is occasionally found inside, on the interface card). The user sets this switch to a number between 0 and 30. This sets the listen and talk addresses of the device; the instrument interface is responsible for setting the sixth and seventh bits to differentiate between listener and talker.

A standard is a detailed specification of the most important mechanical, electrical, and functional aspects. It should detail the function of a device without forcing the manufacturer into using a particular design or circuit.

Secondary addressses are set in a similar manner. Not all instruments have switch-selectable addresses; some have fixed addresses that cannot be altered. Also, if there are two primary addresses, the first is determined by the user; the second is the next in sequence. (In that case, a four-pole dipswitch is used.) Finally, all primary addresses must be unique, but secondary addresses can be duplicated.

Note that 31 is not an allowed primary address. It is reserved for the two unaddress commands, untalk (UNT) and unlisten (UNL). (The two unaddress commands are, in a sense, addresses.) UNT unaddresses the current talker and UNL unaddresses all listeners. The ASCII codes are "?" for UNL and "_" for UNT. Unlisten is usually sent at the beginning of each command string when listeners and talkers are designated. Untalk is rarely necessary, as addressing a talker automatically unaddresses the previous one, and using it slows down handshaking. It is useful when it is desirable to remove all talkers from the bus. For example, untalk might be used to suspend data output from a device.

Handshaking

We now come to one of the more important aspects of the 488 bus and one that makes it unique—the three-wire handshake. We need to understand it to know how the sources and acceptors communicate, and how instruments with very different transfer rates can share the bus without loss or duplication of data.

Two of the three handshake lines must have open collector drivers. As mentioned, they can be thought of as being "wired-or": more than one device can assert these lines, and an asserted line is not released until all instruments release it. As we'll see, this allows for asynchronous data transfer at a rate that automatically adjusts to the speed of the slowest addressed listener or, for universal commands, to the speed of the slowest instrument. Because of this, the transfer rate is extremely device-dependent.

The first of the handshake lines is called DATA VALID (DAV). This line is controlled by the source: the active talker or the controller as talker. It indicates to the listeners when the data on the signal lines are valid.

The second of the handshake lines is NOT READY FOR DATA (NRFD). This line is controlled by the acceptors: the active listeners or the controller as listener. A device releases this line when it is ready to accept data. Since this is an open collector line, all instruments must release the line before it will go false. False means that every acceptor is ready for the next character. The source tests the line and, if it is asserted, no change of data takes place.

The final handshake line is NOT DATA ACCEPTED (NDAC). This line is also controlled by the acceptors. It is released by an instrument when it has accepted the data byte. Again, it is open collector and will not become false until all intruments release it. When false, it means that every acceptor has accepted the current character.

These three lines ensure that no data is lost, that each device gets every byte no matter how slowly it transfers data, and that no device receives a byte more than once. To understand this, and to see how these lines are used in the handshake, we will describe a handshake cycle using the timing diagram in Figure 5 and the flowchart in Figure 6. In the following discussion, the numbers in parentheses match those in the timing diagram.

We assume at the start that the acceptors have set NRFD and NDAC low (true) and that the source has set DAV high (false). As soon as the slowest acceptor is ready for new data, it releases NRFD; since the faster acceptors have already released it, this line goes high (false) (1). The source sees NRFD high and knows that all the instruments are ready. It puts the new byte on the data lines and sets DAV low (2), telling everyone that

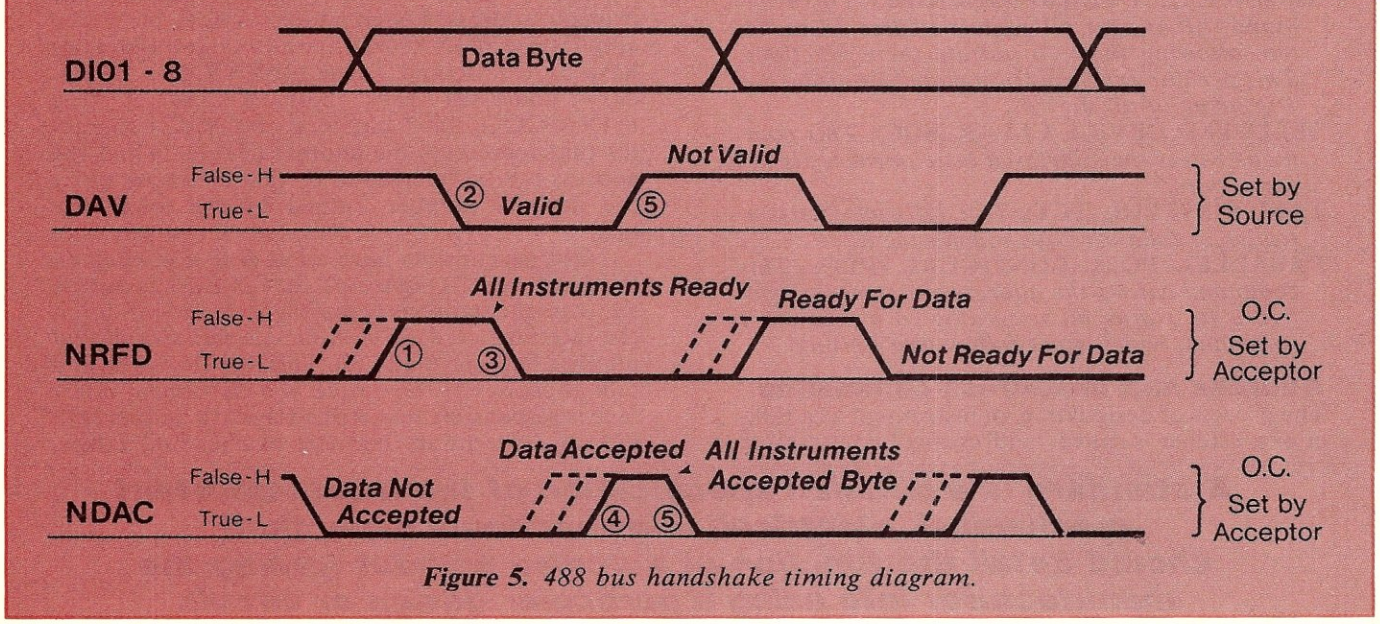

Figure 5. 488 bus handshake timing diagram.

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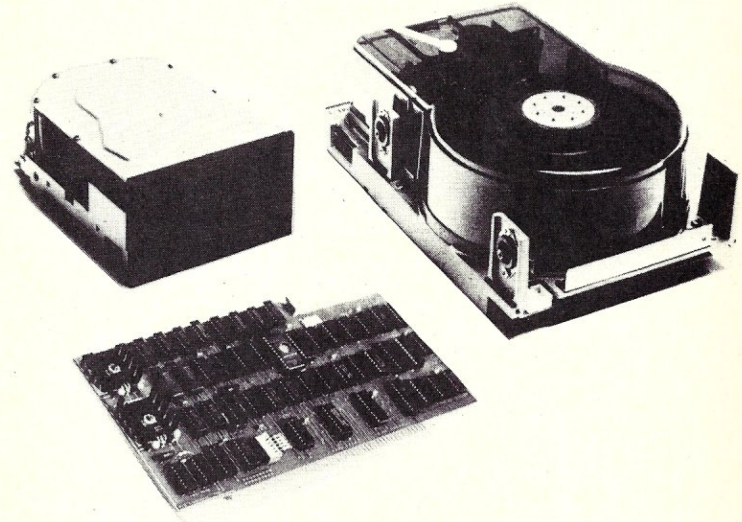

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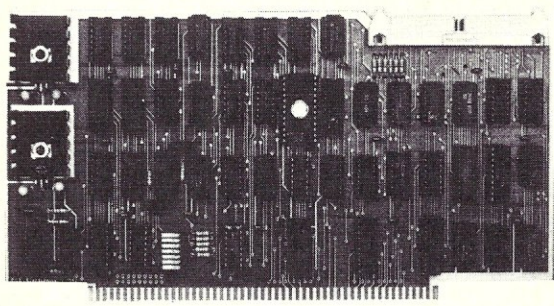

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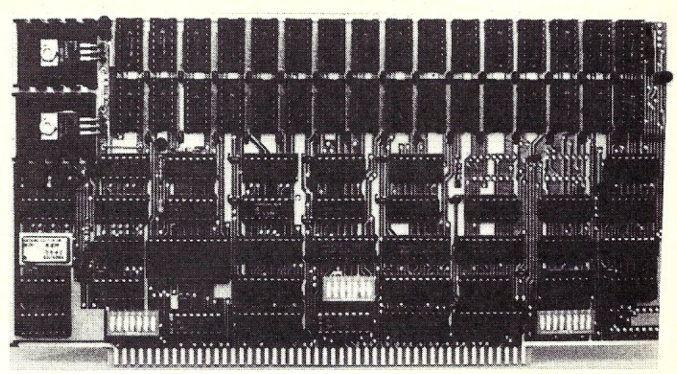

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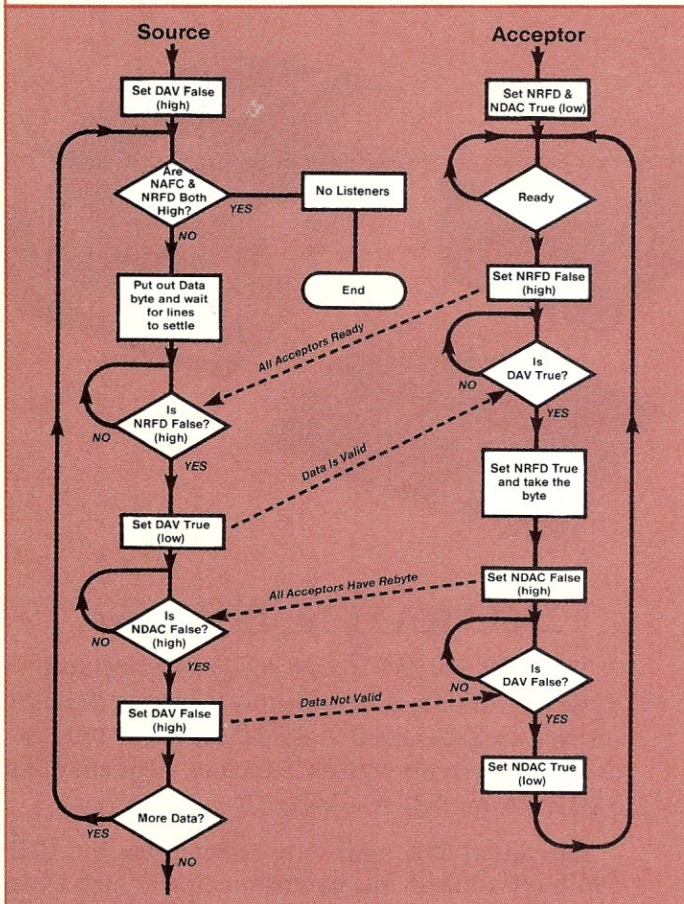

Figure 6. *488 bus handshake flowchart.*

the data is valid. The acceptors see DAV true and the fastest acceptor sets its NRFD true; the others follow (3). This prevents the source from attempting a new transfer. The acceptors begin to take the data at their own rates, and, as each acceptor takes the byte, it releases NDAC. When the slowest acceptor has taken the data, NDAC goes false (4). The source sees NDAC high, knows that all the instruments have now accepted the data, and sets DAV high (5), indicating that the byte is no longer valid. The fastest acceptor sets NDAC low in preparation for the next cycle and is followed by the others (6).

The controller, therefore, never puts a new byte onto the bus until the slowest instrument has accepted the old one. An acceptor, once it has taken a byte, cannot take another until the it sees DAV switch. This cannot happen until the source sees that all the acceptors have the byte. This prevents an acceptor from receiving the same byte twice.

If a talker tries to send a character and there is no listener, NRFD and NDAC will both be high. This situation, which will never occur if there is an acceptor to perform the handshake, will generate an error and stop all bus operation. The error occurs when there are no instruments on the bus, when there is no instrument at the designated address, or when a talk-only instrument is on the bus.

Polling

Polling is used to determine a device's status. There are two ways to take a poll. The controller can query each instrument in sequential order (Serial Poll) or in groups (Parallel Poll). The two methods often have an important difference (besides the serial/parallel nature): an instrument that can respond to a serial poll can, at any time, inform the controller that it needs service (via SRQ). An instrument that responds to a parallel poll usually does not have the service request function, and the controller, not the device, must initiate the poll.

Serial polls

Devices request service by asserting SRQ. The controller can periodically check SRQ or it can be used as an interrupt. Because there is only one SRQ line and because several devices can assert SRQ at once (it is an open collector line), the controller must have some way to identify the devices requesting service. It does this with a serial poll, polling all the active instruments in a user-determined sequence. As it polls each instrument, it reads its status byte. Bits 1-6 and 8 of the status byte are set or cleared to indicate specific functions of the instrument, as determined by the manufacturer. Bit 7 is always set when SRQ is asserted. The controller identifies the requestor by checking bit 7. SRQ can only be cleared by polling the requesting device, and therefore a poll is necessary even if only one instrument is on the bus.

To perform a serial poll, the controller first sends serial-poll-enable (SPE), which places all devices into the serial poll mode. It then sends the first device's talk address. This causes the instrument to place its status byte on the bus. The controller reads the byte and determines if this is the device requesting service. If the device is not requesting service, the controller moves to the next specified device. If it is requesting service, the controller can interpret the rest of the status byte to determine what action to take, or it can ignore the instrument and continue. When polled, a device requesting service releases SRQ. Since the line is open collector, it does not become false until all instruments requesting service have been polled. The controller should test SRQ and continue the poll until it has polled and either serviced or ignored all the instruments requesting service. When the poll is finished the controller sends serial-poll-disable (SPD), followed by UNT, to return to the data mode.

This can be a lengthy procedure in a large sys-

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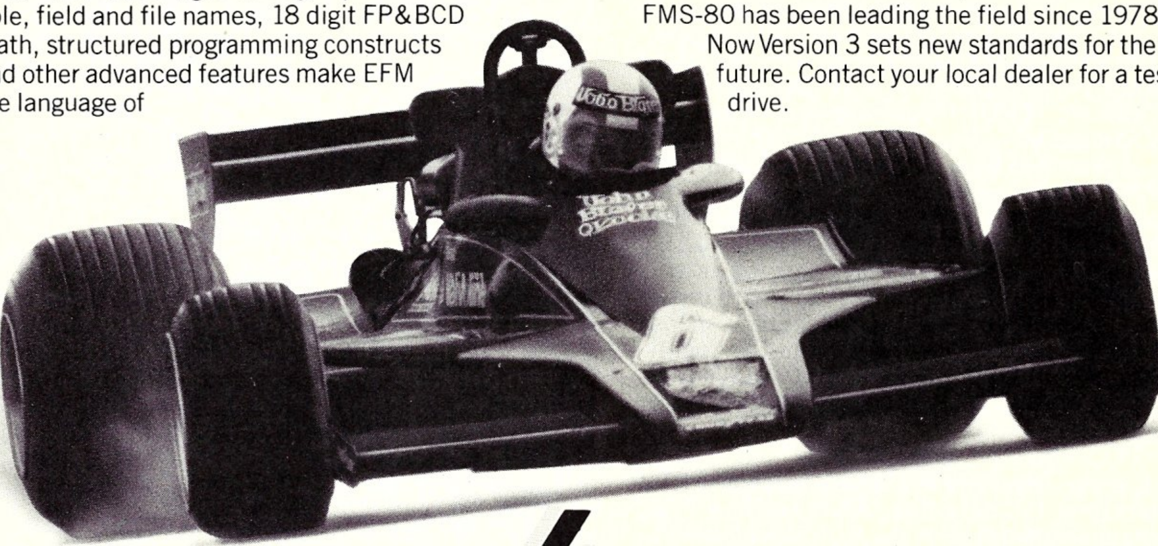

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tem, but has the advantage that the nature of the request is known at the same time as the identity of the requestor. Proper polling strategy depends on a number of criteria. The most important are how many devices must be polled; how fast, and when, is it necessary to act after SRQ is asserted; and what system speed is wanted. There are two basic strategies:

—*Poll all devices and act after the poll is finished.* This is the simplest method, and it requires storing all the status bytes in an array and evaluating them after the poll. No action is taken until the poll is terminated.

—*Poll each device and take immediate action.* This is the fastest response to a device's service request and is the best method when catastrophic failure might result if immediate action were not taken. The tradeoff for speed is the relative complexity of the programs, because SPE, SPD, and UNT must be sent repeatedly.

Parallel polls

Performing a parallel poll is somewhat more complicated than a serial poll; the instrument must first be configured to respond properly. Instead of a status byte, each instrument has a status bit. Its meaning is determined by the manufacturer, but is usually a service request. The device uses its status bit to set or clear one of the eight data lines. Each device can be assigned its own data line: the devices can all be assigned to one line or any combination of the two. The parallel poll response can be configured with hardware, using switches or jumpers in the instrument, or with software. In the latter case it must be done at the beginning of the command sequence, before the instrument is used.

A parallel poll is configured with software as follows. First, the device to be configured is addressed as a listener, and parallel-poll-configure (PPC) is sent. This causes the addressed device to go to the "parallel-poll-addressed-to-configure" state. In this state the device obeys the secondary commands parallel-poll-enable (PPE) and parallel-poll-disable (PPD). These are part of the secondary command group (Table 2). (Note that when not preceded by a primary command, in this case PPC, these codes are the secondary addresses.) The second step is to send one of the parallel-poll-enable commands (60H-6FH). These commands do three things: They tell the instrument which of the eight data lines to use to report its status bit, what sense the parallel poll response should be, and place the instrument in the "parallel-poll-standby" state wherein it is ready to be polled. The PPE commands can be represented in binary as

X 1 1 0 S P1 P2 P3,

where S is the sense and the binary value of P1 P2 P3 determines the data line. After sending PPE, the controller unaddresses the instrument and repeats the procedure for all instruments in the poll.

When the controller decides to take a parallel poll, it asserts ATN and EOI. This causes all devices in the parallel poll standby state to set or clear their lines on the data bus according to the sense bit in the PPE command. If S=0, the instrument sets its assigned data line if its status bit equals zero when it is polled. If S=1, the instrument sets its data line if its status bit equals 1 when it is polled.

This is best seen by example. Consider two instruments, one at address 10 the other at address 20. Assume we configure instrument 10 to report on line 1 with S=0 (SPE=X1100001="a"), and we configure instrument 20 on line 3 with S=1 (SPE=X1101011="k"). When the poll is conducted, the byte received will be 00000Y0X, where

X = 0 if instrument 10's status bit is 1;
X = 1 if instrument 10's status bit is 0;
and
Y = 0 if instrument 20's status bit is 0;
Y = 1 if instrument 20's status bit is 1.

The controller reads the byte and takes appropriate action.

The controller can disable the parallel poll response in two ways. It can address all or some of the previously configured instruments, issue PPC, and then issue parallel-poll-disable (PPD,70H). This command places the addressed instruments in the "parallel-poll-addressed-to-configure" state into the "parallel-poll-idle" state. Or, it can send

Table 3. Subsets of the Pickles & Trout 488 Basic routines, DEC MINC Basic, and RT-11 subroutines and commands

```
                    Pickles and Trout:

CNTL("command")........... Enter command mode and send command
TALK("message") .......... Send a message in data mode
LSTN("message") .......... Receive a message in data mode
SPOLL("msg","tlkrs") ......Perform a serial poll
DREN ..................... Disable remote
REN  ..................... Enable remote
IFC  ..................... Interface clear

                    MINC BASIC:

ALL_INSTRU_CLEAR
DISABLE_REMOTE
ENABLE_REMOTE
IEEE_BUS_CLEAR
LOCAL_LOCKOUT
RECEIVE(message, length, talker, listeners)
SEND(message, listeners)
SERIAL_POLL(status,index,talkers)
SET_TERMINATORS(terminators)
INSTRU_TIME_LIMIT(New limit, old limit)
TRIGGER_INSTRU(listeners)

                    DEC RT-11 FORTRAN:

IBIFC ........ Interface Clear
IBREN ........ Enable remote
IBLLO ........ Local lockout
IBDCL ........ Device clear
IBUNT ........ Untalk
IBUNL ........ Unlisten
IBGET(instru). Trigger
IBSRQ(N) ..... Service request
IBSEND(msg array, msg length, listeners)
IBRCV(msg array, length limit, talker, listeners)
```

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the universal command parallel-poll-unconfigure (PPU), which directly takes devices in the "parallel-poll-standby" state and puts them into the "parallel-poll-idle" state.

Bus operation

The actual programming and operation of an instrument system is clearly dependent on the instruments used and on the software supplied by the bus manufacturer. The software must be able to address the instruments, send device-dependent and interface-dependent messages and commands, and handle SRQ interrupts. It is also useful to have a simple (preferably numerical) addressing scheme and high-level commands. In our experience, the manufacturer of the controller usually supplies "reasonably good" high-level software support, and often supplies very detailed and sophisticated support.

By "reasonably good" support, we mean simple, callable Basic or Fortran subroutines that allow the user to transmit command strings, and send and receive message strings, by using them as arguments in subroutines that handle all the bus management chores. This is the approach usually taken by manufacturers of S-100/488 converter cards such as Pickles & Trout, and by manufacturers of programmable calculators, such as Hewlett-Packard. A sense of what is available can be obtained from Table 3, which shows a subset of the subroutines provided by Pickles & Trout for its bus.

At the other end of the spectrum, manufacturers of complete computer systems often supply very high-level and sophisticated software. Table 3 also shows a subset of Digital Equipment Corporation's (DEC) MINC Basic commands and its RT-11 Fortran subroutines. The command and subroutine names and variables displayed in the table give one the flavor of what is available.

These three software packages show a gradation of software sophistication. At the lowest level shown—the Pickles & Trout routines—the user must transmit the ASCII code for every bus command he needs and handle all error checking himself. This requires the user to understand the bus fully. Alternatively, in the DEC MINC commands, all the work is done for you. In fact, all the bus commands are essentially self-descriptive. In using these advanced routines, the user doesn't have to supply the ASCII commands to operate the bus, address the devices, etc. He only has to provide the message string and address numbers or, in some cases, he simply has to give the command. A price is paid for all this sophistication and ease of use: it severely slows down bus transactions. High-level programs often send unnecessary and repetitive commands to ensure user flexibility. For example, they may send far too many UNT/s and UNL/s. On the other hand, such software is simple to use for novices and those who wish to get a system up with a minimum of fuss.

It is worth remarking at this point, that if speed is important, the fastest and most direct method is to write your own assembly language routines and do your own bus management. This is rarely done.

The best way to illustrate a typical bus transaction is to discuss the operation of a simple instrument system. The first problem one must discuss is software. No two manufacturers of controllers use the same software routines or commands. For descriptive purposes we will invent six Basic 488-bus commands. We will assume they handle all bus management tasks (setting ATN, etc.). These commands are:

- CMD\$("command") sends the string "command" and places the bus in command mode.
- SEND\$("message") transmits a string "message".
- RECV\$("message") receives the string "message".
- SRQ(N) tests SRQ and sets N=1 if it is asserted.
- REN places all instruments into remote.
- IFC clears the interface.

These are not the only Basic commands we could define, but they are adequate to describe a typical bus transaction. Note that we are assuming that SRQ does not interrupt the processor.

The instrument system we will consider is used to measure the current-voltage (I-V) characteristics of a specimen. It consists of a controller (a microcomputer with a 488 interface), a Hewlett-Packard 3465A digital voltmeter (DVM), a Hewlett-Packard 9872A digital plotter and a voltage-programmable current supply. The first two instruments are 488-bus compatible and can talk, listen, and respond to a serial poll. The DVM can be extensively programmed. Table 4 shows the 488-bus functions each device can perform, and Table 5 shows some of the DVM programmable functions and their codes. For simplicity, we will assume that the current source supplies a current directly proportional to a programming voltage and is not 488 compatible. We will assume that a suitable D/A converter exists in the computer and use it to operate the supply.

Suppose we wish to take and plot a series of data points. We will vary the current, measure the induced voltage and plot the point. Assume the la-

Table 4. 488 bus functions supported by the digital voltmeter and plotter

DVM Bus Functions:	Plotter Bus Functions:
Talker	Talker
Listener	Listener
Source Handshake	Source Handshake
Acceptor Handshake	Acceptor Handshake
Service Request	Service Request
Remote/Local	Parallel Poll
Device Clear	Device Clear
Serial Poll	Serial Poll
Trigger	

In high-level driver routines, the work is done for you— all the bus commands are essentially self-descriptive.

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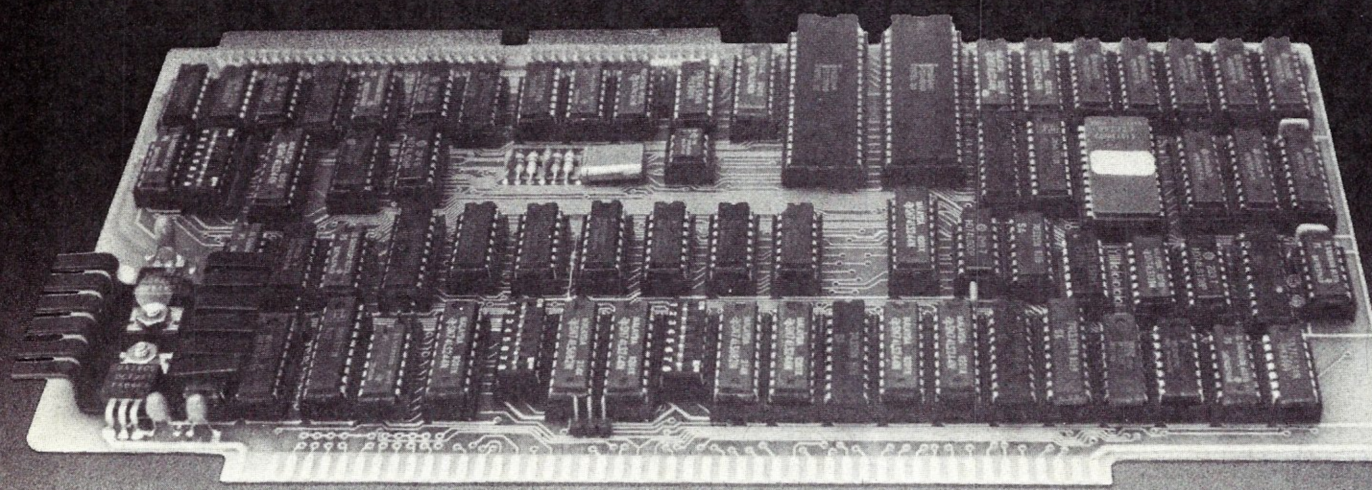

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Table 5. Program codes for the digital voltmeter

Name	Function	Program Code
Function	DC volts	F1
	AC volts	F2
	AC+DC	F3
	2 wire K-ohms	F4
	4 wire K-ohms	F5
Range	Auto	R1
	100mV or 0.1K	R2
	1000mV or 1K	R3
	10V or 10K	R4
	100V or 100K	R5
	1000V or 1M	R6
Trigger	Internal	T1
	External	T2
	Single	T3
	Hold	T4
Autozero	On	Z1
	Off	Z0
Math	Off	M0
	Pass/Fail	M1
	Statistics	M2
	Null	M3
EOI	Enable	O1
	Disable	O0

bels and axes are already printed on the plotter paper, with the origin of the axes at the plotter's origin (let's not get too complicated), and assume the scale factor (voltage and current to plotter units) is known.

Before we run the program, we must set up the instruments and learn how to talk to them. We set the rear panel switches to addresses 10 for the DVM and 20 for the plotter. This gives us a listen address of "*" for the DVM and a talk address of "J". The plotter has a listen address of "4" and a talk address of "T". As we will want to perform serial polls, we need to how the instrument's status bytes are defined; these are shown in Figure 7. Each of the instruments allows the user to determine which status functions will result in a service request. The devices have a status mask for this purpose; it is programmed at the beginning of bus operations. Finally, we need to know how to send and receive data from the DVM and the plotter; that is, we need to know the format and syntax of the messages. The DVM data message consists of 14 bytes:

$$\pm \text{D.DDDDDDE} \pm \text{D CR (EOI) LF.}$$

If EOI is used, it is set when LF is sent; in our DVM its use is optional and we will disable it. The DVM programming message consists of ASCII codes as displayed in Table 5. We need five of the plotter graphics messages: "PAX,Y;", "PU;" and PD;", "IM,X,Y,Z;" and "IN;". PA means plot absolute: the pen is to go to the platen position represented by the integers X and Y. PU is pen up and PD is pen down. IM sets the status, error, and poll masks to the integer values X, Y, and Z, and IN initializes the plotter. The semicolons are required by the plotter to indicate the end of a graphics command.

With these messages we can write a short sample program. While the program could not actually be used, it illustrates how one sends messages and commands and controls a system. In the following, the routine CURRENT sets the current supply and the routine SCALE converts the real variables voltage and current (I and V) into the appropriate integer plotter units (I% and P%).

```
10   IFC
20   REN
30   CMD$(14H)
40   CMD$("*")
50   CMD$(11H)
60   SEND$("F1R4T4M0Z0O0SM36";0DH;0AH)
70   CMD$("?4")
80   SEND$("IN;IMXX,YY,00;")
90   FOR I=0 TO 100
10   CALL CURRENT(I)
110  CMD$("?*",08H)
120  SRQ(N)
130  IF N=0 THEN 120
140  CMD$("?";18H;"J")
150  RECV$(ISB)
160  CMD$(19H;"_")
170  IF ISB¼½68¯THEN CALL ERROR(ISB)
180  CMD$("?J")
190  RECV$(V$)
200  V=VAL(V$)
210  CALL SCALE(I%,V%,V,I)
220  CMD$("?_4")
230  SEND$("PU;PAI,V;PD;PU;")
240  SRQ(N)
250  IF N=1 CALL ERROR(0)
250  NEXT I
```

As can be seen, programming the system is straightforward. The first two steps clear the bus and put the voltmeter and the plotter into the remote state; they can now be programmed over the bus. The next three commands could have been lumped together into one long string. First we clear the instruments, returning them to their default modes. We then address the DVM as a listener (40) and lock out its front panel (50, 11H=LLO). Next we program the DVM. We send a string of alphanumeric characters, which program it to measure D.C. volts on the 10V full-scale, hold the trigger, turn off all math functions and the auto zero, and disable EOI. The final five bytes set the status mask to determine which of the items in the status byte will set SRQ. In this case we have set it for DATA READY and ERROR (see Figure 7). The next two steps program the plotter's status mask. We have set it so only an ERROR or OUT-OF-RANGE will set SRQ. We ignore the error and poll bytes.

The next step is to set up a loop to take and plot the data. Line 100 programs the current supply (perhaps I is the number of milliamps put out by the power supply). The DVM is then triggered

An effort is now underway to provide standardized guidelines for the preferred syntax, format, and terminators for bus terminals.

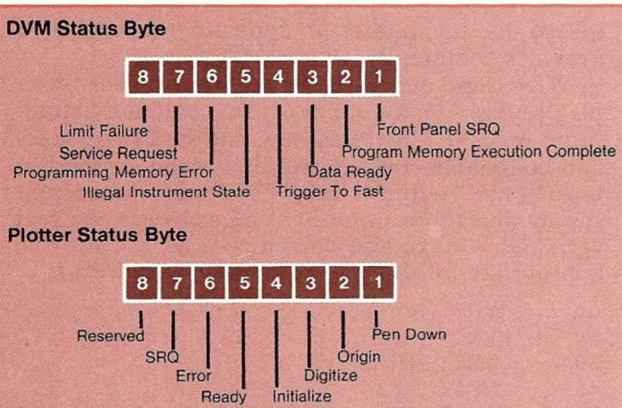

***Figure** 7. Digital voltmeter and plotter status bytes.*

(110) and it starts its conversion. The computer must now check SRQ and loop until the DVM requests service (120-130). This step is critical for our program and illustrates two of the problems one faces. First, compared to the computer, most measurement and test instruments are very slow; in this case, a complete DVM conversion can take several seconds. The computer must wait for it to signal that it has the data. Second, in this case and in other similiar situations, there is nothing to be gained by using SRQ as an interrupt: The computer has nothing better to do than wait.

Eventually, the DVM will assert SRQ, N will be returned as 1, and we fall through to line 140. At this point we must perform a serial poll, even though we know the DVM asserted SRQ. This is to get the DVM to release the SRQ line. We issue serial poll enable (140, 18H = SPE) and address the DVM to talk. We then get the status byte (150) and issue serial poll disable (19H = SPD) and untalk. Line 160 checks the status byte: if any but lines 3 and 7 are set, a branch to an error routine occurs. If there is no error, we address the DVM to talk (180) and get the data (190). The program then converts the data to numeric form (remember, the instrument transmits it as an ASCII string) and calls SCALE to convert the voltage and current to plotter units.

The next several steps plot the data. We untalk the DVM and address the plotter to listen (220). The plotter instructions are sent: pen up, move to (I%,V%), pen down (marking the point), and then pen up. We check SRQ to see if a plotter error has occurred, branching to the error routine if it has. Finally, we loop back to repeat the process.

The alert reader will have noticed a number of problems—in particular, problems of syntax and format, and problems of "time."

Optimizing a 488 system

The 488 standard describes *how* the instruments talk to one another. It says nothing about *what* they say to one another: message syntax and format are not a part of the standard. This is an important problem, one that actually negates some of the usefulness of the bus and the standard. Different companies can, and do, use different message formats, program codes, and terminators. The codes for data transmission are arbitrary; the only real specification is that the listeners and talkers must agree on the syntax and format. It is very important that the controller software be flexible, or programming can be quite difficult.

There do exist some general guidelines for codes and formats used in programming instruments. In general, instruments are programmed using one or more alpha characters to identify instrument functions, followed by one or more numeric characters which give the parameter value or option. The Hewlett-Packard DVM has such a format (Table 5). Note that even within this guideline, code assignments are still unique to each device. The format for data messages has likewise been somewhat formalized. There is usually a header field of alpha characters, a data field for the measured quality, and a connector or terminator. The header has the information about what has been measured and possible error messages (e.g., overflow). The data field contains the actual measurement. It is generally recommended that the only ASCII characters used for the header and numeric fields be plus, minus, the decimal point, the 10 numerals, and the uppercase alpha characters. Spaces, punctuation, and nonprintable ASCII characters are to be avoided. The separator, used when several readings are to be sent in sequence, is usually a semicolon or comma. Different manufacturers use different terminators, but carriage return and line feed are the most common and usually occur together. Often the terminator in an instrument can be changed with software or hardware jumpers. Of course, EOI can be used if the manufacturer has allowed for it.

An effort is now underway to provide standardized guidelines for the preferred syntax, format, and terminators for bus instruments. (*Note: The IEEE 728/1982 standard has been approved.*)

"Time" is a very important parameter in bus transactions. We are referring to the time it takes an instrument to perform its function and respond to the controller. Many instruments are mechanical and can "hang up." Others can be mistakenly, but properly (i.e., error free), programmed so that they take much longer than expected to perform their functions. To check for this, most software packages have some form of "timeout" comand. This routine allows the user to set a time limit for instrument response; if the time limit is exceeded, the controller will send an error message. DEC's INSTRU_TIME LIMIT is a typical example.

Bus speed, another aspect of time, is also important. What determines the data transfer rate and how can it be optimized? The ultimate transfer rate on the bus is one megabyte/second, a rate

The 488 standard describes how the instruments talk to one another. Message syntax and format are not part of the standard—an important problem.

Z80 Software

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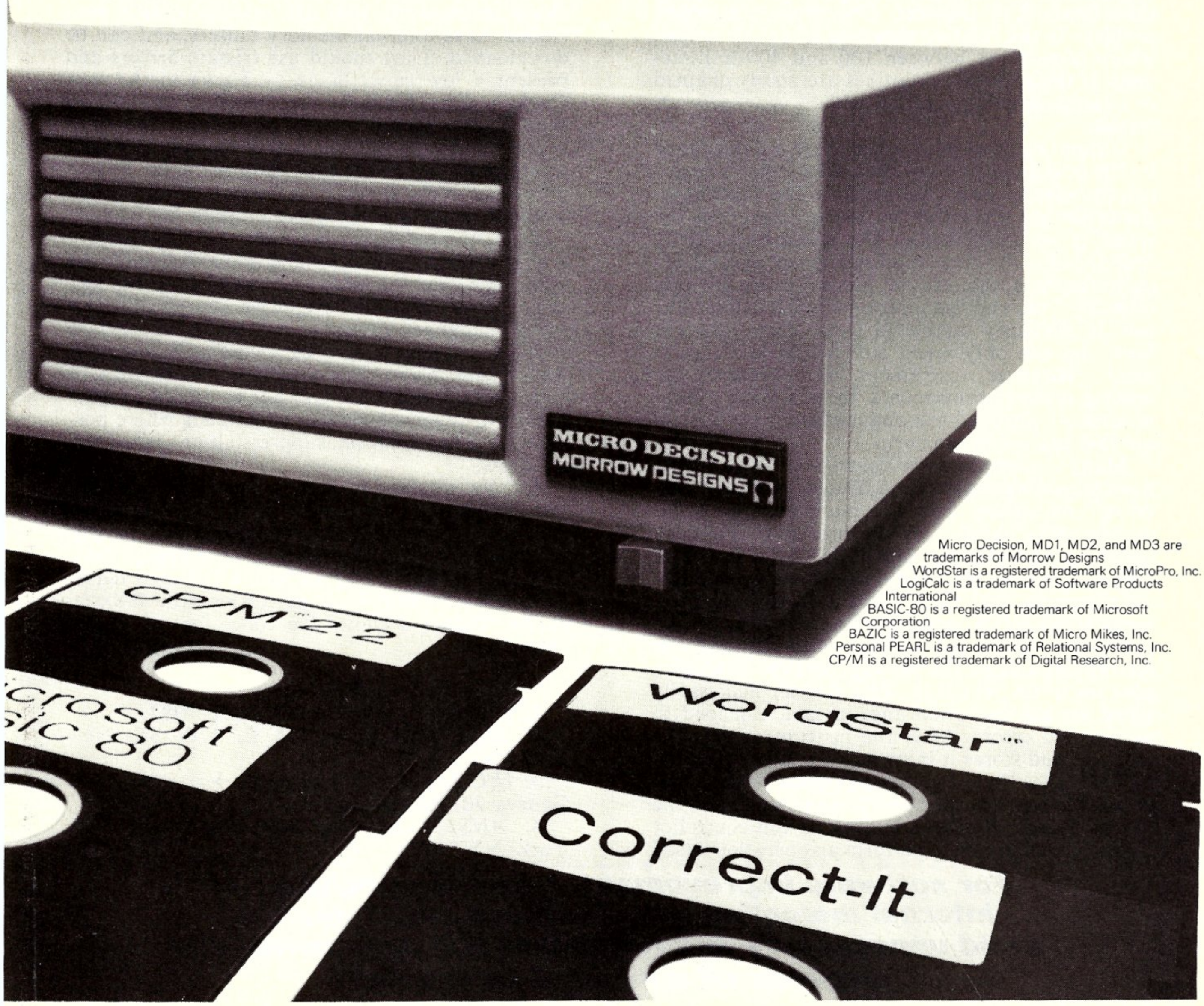


that is very seldom reached in a system of any complexity. More typical rates are 250KB/sec with open collector drivers, and 500KB/sec with tristate drivers. In a given system, the actual speed at which data can be transferred depends on a variety of things, including the controller I/O and processing time, the instrument's speed, and the number of instruments attached to the bus.

Increasing the number of instruments has two effects. The time needed to perform addressing and handshaking increases, and the loading of the bus increases. In the first instance, the handshaking proceeds at the rate of the slowest instrument on the bus. Even if only one or two of the devices are addressed, they all must respond to universal commands. In the second instance each instrument is a capacitive load on the bus, and such loads slow down data transmission. The more instruments, the more serious the problem.

Today's computers have sufficient speed so that they are usually not responsible for slow rates. Nevertheless, a misused computer can severely slow down data transfer. One often overlooked problem is the relative slowness of a disk access, which often takes between 100 and 400 milliseconds. If the 488 driver routines are poorly chained or overlayed, bus operation will be markedly affected.

Ultimately however, the data rate is determined by the instruments themselves. The faster a device can transfer messages and perform the handshake, the faster the job will done. What determines the speed of an instrument? The speed depends on four factors: the time required to set up and acquire the data, the internal process time, the data transfer time, and the interface process time. The user is obviously unable to make many changes here—he can only select sufficiently fast instruments. However, instrument manufacturers are making many improvements. In particular, microprocessor-controlled test and measurement devices are fast becoming the norm.

Many microprocessor-controlled instruments have preprocessors that handle addressed and universal commands, with the more complex commands being handled by the processor. This can speed up handshaking operations by a factor of 100 or so. Such instruments often have small internal memories that allow them to handshake messages at the fastest possible rate and store them in the buffer. When the message is terminated, the instrument acts on the message and the controller goes on to its next task. This doesn't necessarily speed up bus operation and, in fact, can lead to unexpected errors. After the instrument gets the message and stores it in memory, it must evaluate it. This takes time; the message must be read and checked for errors, the operation executed, and the results placed in output buffers. If the controller tells a second device to perform an operation based on the first device's setup, errors will occur if programming delays are not taken into account. Properly used, however, such instruments are significantly faster.

Microprocessor control has led to one very real improvement is bus operation. Many instruments can be programmed to perform fairly sophisticated data reduction and analysis, relieving the computer of this task. The digital voltmeter discussed above is one such device. It can take a large number of readings and perform many statistical analyses of the data. Other devices have memory areas into which the controller can download instruction sets and analysis programs, again saving the computer this overhead.

The ultimate questions to be answered, however, are "How do I improve the speed in my system?" and "Can I go beyond 500KB/sec?" The answer has two parts: hardware improvements, which are not always accessible, and software improvements, which can always be employed. On the hardware side, one should, if possible, purchase instruments that are microprocessor controlled, have internal memory buffers, and can be downloaded. They should use tristate drivers and present a low capacitance (<50pF) to the bus. Cable lengths should be kept below 15 meters and should never exceed 1 meter per device. The number of devices on the bus should be kept to an absolute minimum, and they all must be on. If it is necessary to use slow devices along with fast ones, consider using two 488 buses on separate ports.

From the software viewpoint, take full advantage of internal memories and download smart devices. Whenever possible, interrupt drive the system. Use as many low-level drivers as possible (assembly language routines) and, when higher level routines are adequate, used a compiled language. Avoid unnecessary and redundant bus commands and UNTs and UNLs. Use bus commands rather than instrument-dependent commands where possible. Last but not least, suppress all unneeded terminators.

Finally, we should comment on a nonmandatory but frequently used aspect of the revised IEEE standard. It provides for "capability ID" on the rear panel of all instruments. The interface function codes (Table 1) for all functions supported by the instrument may be displayed near the 488 connector. Figure 4 shows the codes for the digital voltmeter.

References

1. S. Leibson, *Byte,* Vol. 7, April 1982.

2. *IEEE Standards*, 345 E. 47th St., New York, NY 10017.

3. *IEC Standards*, 1, Rue de Varembe, 1211 Geneva 20, Switzerland.

4. *ANSI Standards*, 1430 Broadway, New York, NY 10018.

For software improvement, take full advantage of internal memories and download smart devices; avoid unnecessary and redundant bus commands; and suppress all unneeded terminators.

IEEE-488 Bus Tutorial continued . . .

Other reading

Tutorial Description on the Hewlett-Packard Interface Bus. Available from the Hewlett-Packard Company, this booklet has an extensive bibliography on HPIB articles and instruments.

"Understanding IEEE-488 Basics Simplifies System Integration." June and August 1982 issues of *EDN.*

Introduction to the GPIB. Available from the Wavetek Corporation.

Interfacing to the Interface: Practical Considerations Beyond the Scope of IEEE Standard 488. T. Coates, Wescon 75 Conference.

Richard S. Newrock is professor of physics and department chairman at the University of Cincinnati. He received a B.S. in physics from Rensselaer and a Ph.D. from Rutgers. After several years of post-doctoral research at Cornell University, he joined the faculty at Cincinnati. An active researcher, he is currently involved in investigations into two-dimensional physics and topological phase transitions in superconducting arrays and granular metals. He uses microcomputers extensively in the laboratory, office, and home for word processing, database handling, scientific calculations and experimental control and data taking.

Interfacing Microcomputers with Laboratory Instruments

by Joseph W. Long

Within the last six years, the microcomputer has rapidly developed into a very important laboratory tool, since the cost of microcomputer software and hardware has been steadily dropping while its computing power has increased. Much of the new chemical instrumentation currently entering the market is microcomputer-controlled. Here at Broome Community College, examples of such equipment in our Chemical Technology laboratories run all the way from programmable pH meters to a very sophisticated Perkin-Elmer computerized infrared spectrophotometer.

However, to keep the education of our students abreast with the state of the art, we decided that student involvement with microcomputers beyond the commercially available "off the shelf" equipment was desirable. For this purpose, two microcomputer-controlled laboratory instrumentation systems were constructed for the use of second-year chemical technology students. The first consists of a Gow Mac Gas Chromatograph interfaced to a Processor Technology microcomputer and functions as a "smart" gas chromatographic data analyzer, collecting and processing data in real time. The second system consists of Nucleus scintillation equipment interfaced to a North Star Horizon microcomputer; it functions as an intelligent gamma scintillation spectrometer.

The idea was to interconnect a microcomputer with older instruments already on hand, thus showing students directly how computers can increase the power and versatility of existing equipment. One advantage of using a separate microcomputer connected to a piece of equipment is that students are able to see much more clearly how the computer and instrumentation are interrelated physically, logically, and electronically. Another is that it gives students a chance to study the control programs and modify the software to improve or extend the operation of the system. The control programs in commercially available equipment are often inaccessible to students, due either to their proprietary nature or to the fact that they are frequently written in an assembly language and stored in ROM.

We acquired our first microcomputer during the fall of 1977. The hardware and software were prepared over the summer and fall of 1979, while the first student use of this equipment took place during the 1979-1980 academic year.

Gamma scintillation spectrometer

The microcomputer-controlled gamma scintillation spectrometer, a scheme of which is shown in Figure 1, consists of a North Star Horizon II microcomputer interfaced to Nucleus scintillation equipment. (Interface hardware will be discussed later.) The Nucleus equipment includes a sodium iodide detector, pulse height analyzer, ratemeter, and chart recorder. The microcomputer contains 64K of RAM, an eight-channel digital-to-analog/analog-to-digital converter (ADC/DAC), and a high-resolution graphics video terminal.

Joseph W. Long, Broome Community College, Box 1017, Binghamton, NY 13902

Spectra may be run completely under control of the microcomputer. Controllable parameters include scan speed, scan energy limits, scan output media, etc. Available output media include the chart recorder and/or low- or high-resolution graphics on the video terminal. Once scanned, spectra may be saved on disk (over 250 spectra per quad-density disk) for subsequent re-examination. Disk spectra consist of 255 data points, where each point is resolved to one part in 2^8. A typical spectrum replotted from disk is shown in Figure 2.

The Basic program that controls the spectrometer requires about 52K of memory. The control program includes continuous display of prompt lines, making the system very simple to operate. The self-prompting nature of the programs makes it possible for a student to operate the spectrometer under computer control, with perhaps 15 minutes of instruction.

Chromatographic data analyzer

The chromatographic data analyzer (Figure 3) consists of a gas chromatograph interfaced to another microcomputer. The gas chromatograph used is a Gow Mac model GC-2, with a strip chart recorder. The microcomputer is a Processor Technology Sol, with 64K RAM and a Helios II dual floppy disk system. Data analysis capabilities of this system include the ability to calculate the relative areas of each peak in a series of a chromatographic run, together with determination of the retention time of each peak. The results of a run may be printed optionally on a teletype terminal for a permanent record. A full set of continuous prompts appearing during execution makes this equipment as simple to operate as the scintillation system.

The software developed for the data analyzer is rather unsophisticated, requiring that three assumptions be met for good results. These assumptions are that the baseline is drift-free, the peaks symmetric, and the signals noise-free. There are two reasons for this lack of sophistication. First, the software is written in Processor Technology Basic, an interpreted language that is too slow to allow much real-time calculating (the amount of calculation increases rapidly with increasing sophistication of the routines). Second, the amount of time required to develop even the simple software used in this project has been very large, and a

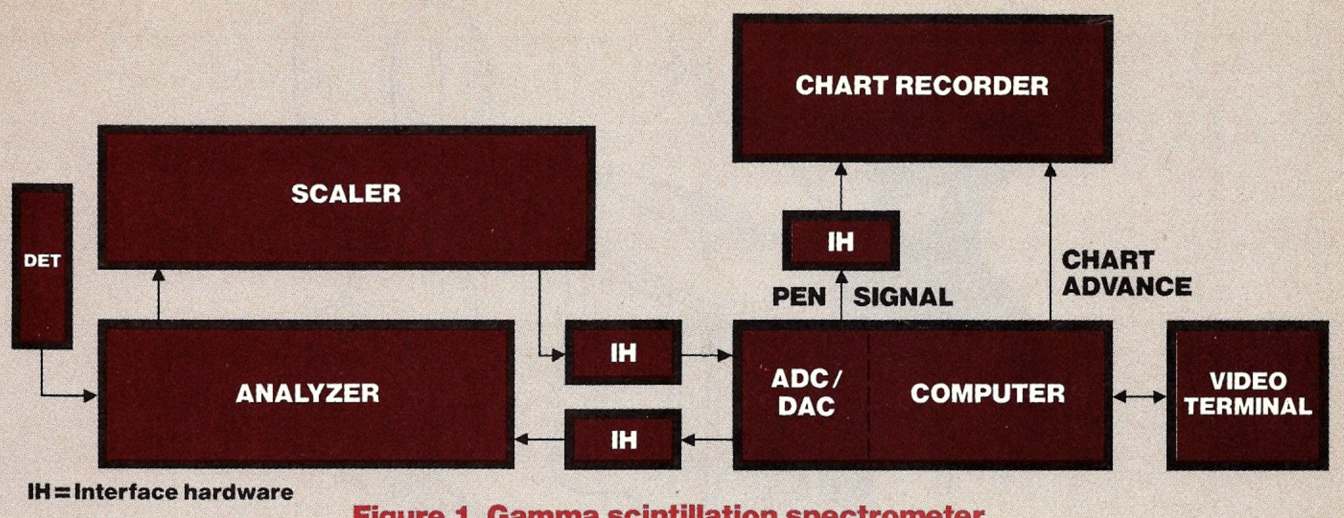


Figure 1. Gamma scintillation spectrometer

great deal more additional time would be required in order to improve the programs significantly.

One interesting aspect of the computers used in this project is their electronic architecture. Both computers consist of a "backplane" into which electronic circuit cards are plugged. Each computer uses the IEEE-696/S-100 bus, for which dozens of manufacturers have produced hundreds of different boards. A computer can be made by plugging into the backplane (also called a "motherboard") the units that comprise a computer: a central processor unit (CPU) board, memory boards, an input/output board, and so on. This approach can produce a custom-built computer having just the specifications a given situation requires. There are a number of advantages to this approach: One is that as technological advances or changing requirements dictate, old boards may be replaced by newer ones, making it impossible for the computer to become obsolete (for a few years anyway!). Another advantage is that troubleshooting is often relatively easy with a modular system of this type, since a board can be swapped from a known good system to one with problems in order to isolate a problem quickly in a given part of the computer.

The alternative approach in terms of architecture is to use one of the "single" board computers, such as the Radio Shack, Heath/Zenith or Apple. In these machines, the entire computer is built onto one or two large circuit boards. One result of this approach is that a computer of this type may be unpacked, plugged in, and run; it is easy to get running. While these are excellent computers and have many good points, from the viewpoint of adaptability, expandability, and ease of repair, they suffer in comparison with a computer using the IEEE-696/S-100 bus. A similar situation exists in buying high-fidelity equipment: One can either buy a package system or opt for "components." The first gives a system ready to operate; the second may want a bit of fiddling to get it going, but has more possibilities.

Design and construction of interface electronics

This phase of the project requires comment in detail because of its critical importance to the project as a whole. "Interface electronics" refers to the circuitry required to interconnect the computer—essentially a digital device—with external items of equipment, most of which are analog devices.

The electronics required to do this comes in two packages. The first in an analog-to-digital/digital-to-analog converter. The converter used in this project, a Cromemco D7A, provides eight channels of analog input to the computer, and eight channels of analog output from the computer—all on a single card that plugs into the computer back-

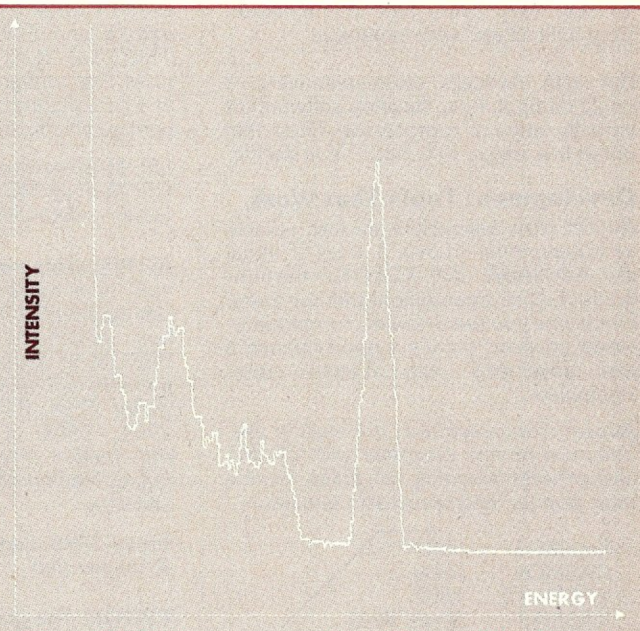
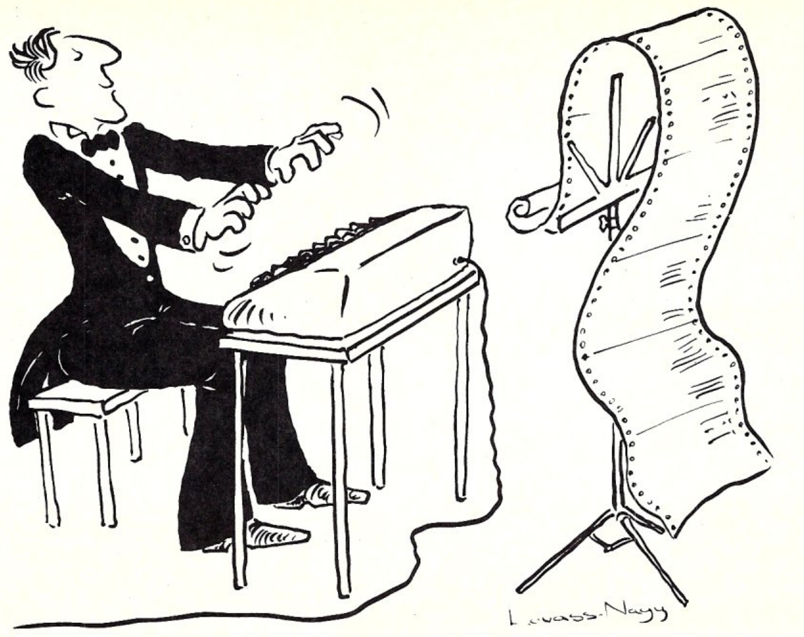


Figure 2. Cs^{137} spectrum replotted from disk. "Steps" are a result of using an 8-bit analog-to-digital converter.

Using a separate microcomputer allows students to see clearly the interrelation between computer and instrument, and gives them a chance to modify the software.



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(Coming soon: XASM68K .... 68000)

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CP/M-80 version $150
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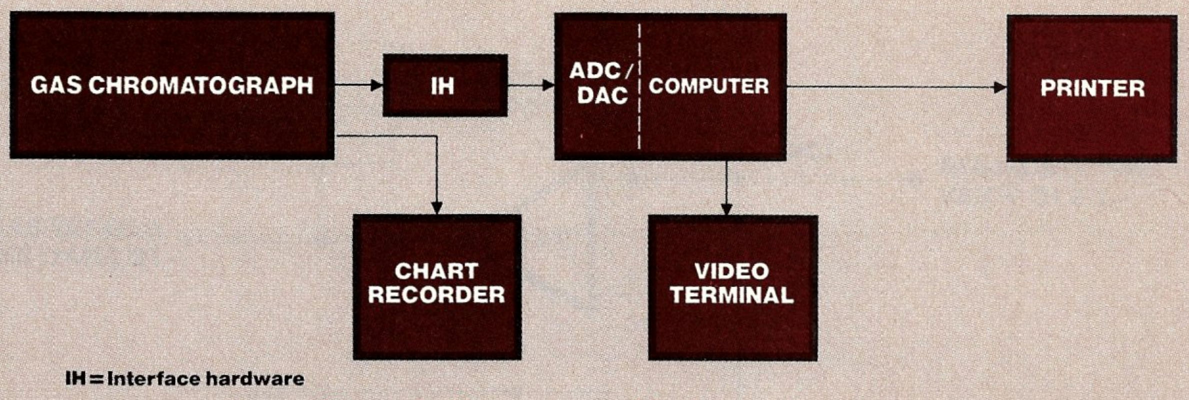
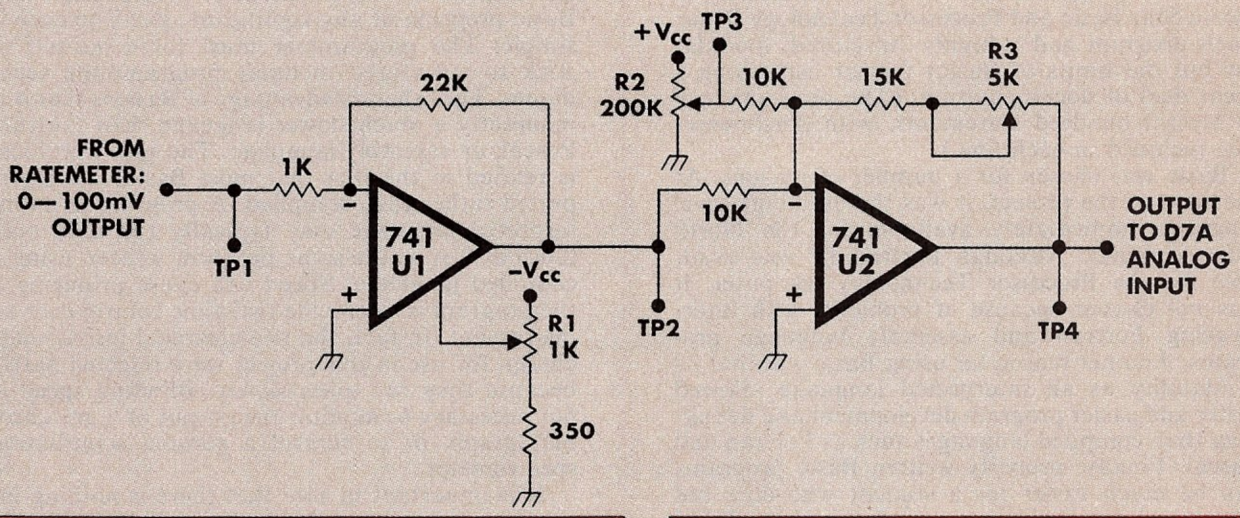


Figure 3. Chromatographic data analyzer

plane. A limitation inherent in the D7A necessitates the second electronics package. The limitation is this: Both the input and output sections of the D7A are designed to function over the voltage range of −2500 mV to +2500 mV. The problem here is that the analog peripherals to be connected to the converter have many different voltage ranges extending, for example, from 0 to 1 mV for output from the gas chromatograph to the computer, to the 0-to-10V range required from the computer to drive the analyzer in the scintillation spectrometer.

Operational amplifier circuits, functioning as inverting amplifiers and/or summing amplifiers (or both) were used to do the required matching between the computer and the peripherals. These circuits were designed using low-cost, easy-to-use 741 operational amplifier integrated circuits. Four such circuits were required for the work done in this project: three in the scintillation spectrometer, and one in the data analyzer.

Examples of the circuits used in the scintillation spectrometer are shown in Figures 4 and 5. The first circuit matches the 0 to 100 mV output of the ratemeter to a ±2500 mV input channel on the D7A. The second converts the DAC analyzer ramp output, which ranges from −2.5V to +2.5V, to 0V to 10 V.



Circuit Theory:

U1 is an inverting amplifier with gain of ~ 22 (TP1 to TP2).

U2 is a summing amplifier with a gain of ~ 2 (TP2 to TP4).

TP	voltage swings
TP1	0 to 100mV
TP2	0 to −2500mV
TP3	1.25V (fixed)
TP4	−2500 to +2500mV

Adjustments:

1. Adjust R2 to give approximately 1.25V at TP3.
2. With TP1 = 0mV, adjust R1 to give 0mV at TP2.
3. With TP1 = 0mV, adjust R2 to give −2.5V at TP4.
4. With TP1 = 100mV, adjust R3 for 2.50V at TP4.
5. Repeat 2 and 3 until:
   TP1 = 0mV gives −2.50V at TP4
   TP1 = 100mV gives +2.50V at TP4.

Figure 4. Ratemeter output amplifier. This circuit converts the ratemeter's 0—100mV output to the −2.5 to +2.5V output needed to drive the D7A analog input. The circuit is built into the ratemeter.

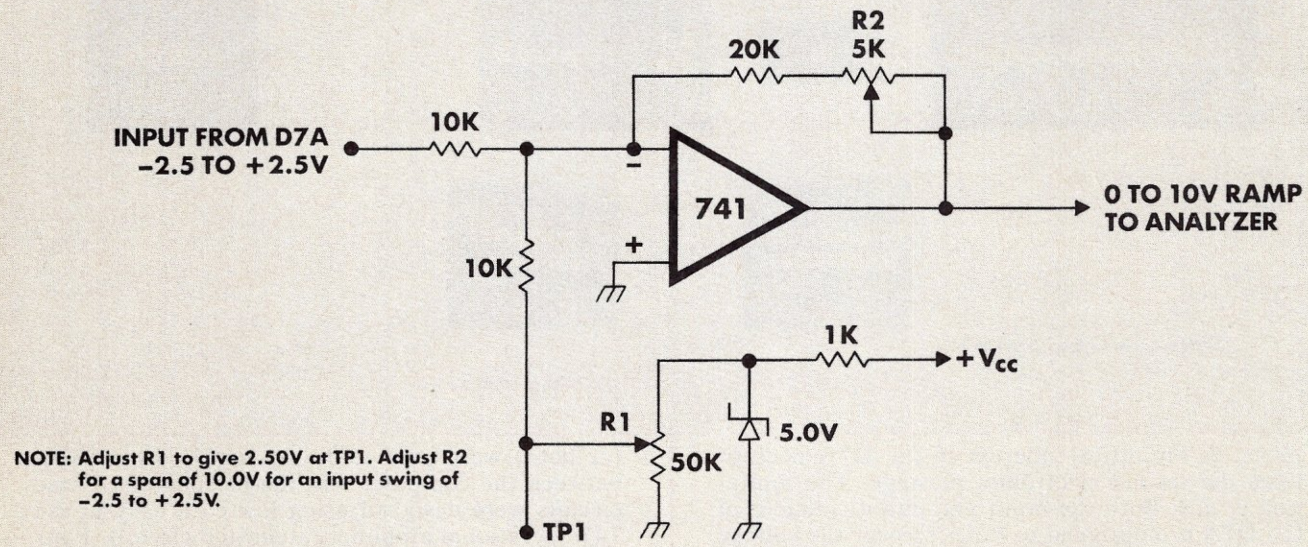


Figure 5. Analyzer ramp interface. This circuit converts a computer-generated ramp signal of −2.5 to +2.5V into a ramp running from 0 to 10V. The circuit was built into the Nucleus Analyzer.

The software

Two main programs were written for this project: one for the spectrometer, and one for the data analyzer. The programs were written respectively in North Star Basic and Processor Technology Basic. Each program had a highly structured, modular (within the limits of Basic) format containing a great deal of documentation. (The programs run to several hundred statements, with documentation included in each line.)

Basic was chosen for a number of reasons. At the start of the project, it was the only high-level language immediately available for the North Star computer. Although Fortran IV was available for the Processor Technology computer, it was not chosen because of problems with interweaving Fortran and assembly language programs. Another reason for using Basic was that its availability as an interpreted language allowed faster and easier program development and debugging than compiled languages such as Fortran and Pascal. Finally, properly written Basic programs can be much easier for a student who does not have much programming experience to read and understand than programs in most other languages. This is important if students are to be able to examine and modify portions of the program within a reasonable period of time.

However, Basic has two disadvantages when used in work of this sort. The first is that Basic has few rules regarding structure or documentation. It is very easy to write Basic programs that are totally indecipherable not only to a student, but also to the programmer after a few days. This problem can impede the development or modification of a Basic program of any significant size. The cure is simple: The programmer must force himself to stick to structured modular programming techniques. The other disadvantage of Basic is that it is inherently a much slower language than Fortran, Pascal, or assembly language. The speed problem is related to the fact that most Basics are interpreted rather than compiled. A program in an interpreted language may typically run only one-tenth as fast as the same program written using a compiled language. Speed can cause problems if the program is to provide real-time control over an instrument. In fact, the two chemical instruments chosen for use in this project were selected partly because they run quite slowly. Blinding speed is not necessary to monitor the output of a gas chromatograph, or to control a gamma scintillation spectrometer.

It is important to note that there is nothing inherent in Basic that requires it to be interpreted. In fact, at least one company (Microsoft, Bellevue, WA) has identical versions of Basic, one interpreted, the other compiled. A program may be written and debugged using the interpreter, then compiled to produce a much faster version for actual use.

Students benefit in two ways: They learn about the advantages of using laboratory computers and, at the same time, are able to do more chemistry because of increased instrument efficiency.

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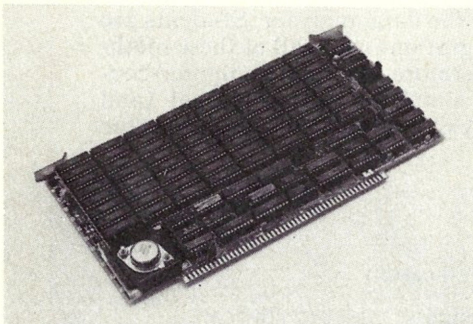


Major breakthrough made by Macrotech International Corporation

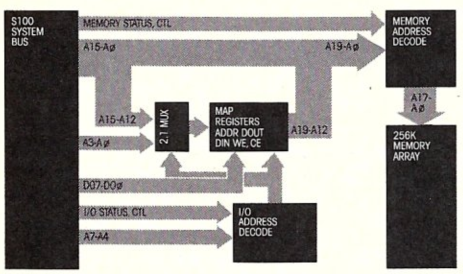
CANOGA PARK (MI)-January 20, 1983-Mike Pelkey, president of Macrotech International Corporation, today announced a major technological breakthrough in S-100 dynamic memory board density. A full megabyte of high speed dynamic ram is contained on a single standard size S-100 multilayer P.C. board. The product, dubbed 'Max' meets all IEEE/696 mechanical and electrical specifications and byte parity generation/checking is included as a standard feature. Max supports IEEE/696 24-bit addressing (selectable at any 128K boundary), 8/16 data transfer protocol, phantom line operation, and the same ultra low noise bus signal filtering provided on Macrotech's popular high performance 256K dynamic memory board.

Max is in production now and shipping at the all-time low cost per bit list price of $1,983 in unit quantity.

Bruce Kimmel, Macrotech's sales manager reports that customers are being served on a "first-in, first-out" basis and warns that due to a high incidence of graphics and similar memory-intensive applications, along with an unwillingness in the trade to pay exorbitant prices for memory, backlogs may occur for Max which could delay shipments against some late orders. With the improbability of second sourcing for some time, interested parties are urged to get orders in as soon as possible. Bruce can be contacted at 22133 Cohasset Street, Canoga Park, California 91303, or reached by telephone at (213) 887-5737.

M³ Family Growing

Another product recently introduced by Macrotech is soaring to the top of the best-seller list. The Multiuser II is a 128 kbyte 70ns CMOS static ram memory board that is unquestionably without peer in the S-100 marketplace. It's a 6-layer board with blazing speed, 8/16 data transfer protocol, and ultra-low power external battery support. The same M³ memory mapped addressing architecture so in demand with system software professionals is now standard in the new Multiuser II. M³ was first developed by Macrotech for the popular Multiuser I 256K dynamic ram board to meet the demanding requirements of today's sophisticated systems.

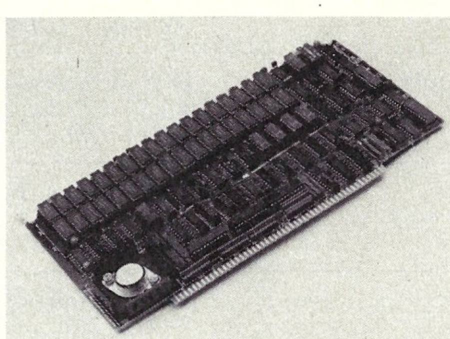


Macrotech's advanced memory mapping scheme allows each 4K block of the 16 bit (64K) logical addresses to be dynamically translated to any 4K block of the physical memory. Global memory can be configured to any size and located anywhere in the logical address space. All remaining memory can be addressed through the remaining logical address space by simply reloading the mapping registers to address the desired physical memory blocks. This scheme permits unlimited use of all on-board physical memory.

Virtual Disk Flexibility Cited

CANOGA PARK-January 20, 1983-Macrotech reports their Multiuser I and Multiuser II S-100 ram memory boards can be used as both system memory and "virtual disk" storage in eight or sixteen-bit applications. Addressing flexibility is the key. The Multiuser M³ memory mapped addressing is guaranteed to allow memory partitioning to fit the exact requirements of your system without ever wasting a single byte.

Today's trend in operating systems appears to include extended memory capabilities to allow for the recent technological advances in semiconductor memory. A close look at Digital Research's new CP/M 3™ for example, would lead you to believe that it was especially created to fit Macrotech's family of Multiuser memory boards. (It wasn't, but try to find one that fits better.)



Where it all started: pictured is the popular Multiuser I, Macrotech's first product. This widely used board provides 256 Kbytes of dynamic ram with 4K page memory mapping (called M³), 8/16 bit operation, 24 bit addressing and byte parity checking.

MACROTECH Announces Distribution Expansion

CANOGA PARK-January 20, 1983-Macrotech is now establishing domestic and international dealer/representative networks. The California based firm is expanding it's customer support through these channels and invites inquiries. Volume users and retailers should contact the company for details.

Macrotech's marketing director Bob Ryle states, "IEEE/696 has made S-100 legitimate. It is rapidly gaining acceptance due to its inherently superior speed characteristics." Ryle attributes the growing demand for Macrotech memories to Macrotech's strict adherence to the IEEE standard.

Further work

This project is part of a continuing series that we are doing at Broome Community College. Previous projects involving computer control and laboratory interfacing include development of a microcomputer-controlled automatic titrator and a constant-current coulometer. Other projects include several computer programs that students can use in laboratory work. One example is a program that assists in the preparation of samples for liquid scintillation counting (LSC); another is a Sartorius Analytical Balance interfaced to a Hewlett-Packard desktop computer. (The latter is a commercially prepared package.)

Project evaluation

Both systems functioned as intended. The gamma scintillation spectrometer even emerged as a much more powerful and versatile system than had been planned, in terms of its capabilities and ease of use, while the data analyzer functioned almost exactly as had been projected.

The primary users of the data analyzer are liberal arts students and chemical technology students in their organic chemistry courses. An experiment comparing simple with fractional distillation includes analysis of samples using the gas chromatograph. Students analyzed their results by integrating peaks on their chromatogram via several methos: cutting and weighing, triangulation, and now, by use of the data analyzer. Students are required to do integrations using all of these methods, and they therefore see the computer-controlled integrator simply as an additional (and very powerful) way of analyzing chromatographic data.

Equipment Suppliers

Equipment	*Company*
Chromatographic data analyzer Processor Technology Sol computer, Helios II disk system	Company out of business. Current source of this equipment: **Computer Port** *2142 N. Collins* *Arlington, TX 76011*
Model D7A digital-to-analog/analog to digital converter	**Cromemco, Inc.** *280 Bernardo Ave.* *Mountain View, CA 94040*
LA 36 Decwriter II printing terminal	**Digital Equipment Corporation** *146 Main St.* *Maynard, MA 01754*
GC-2 Gas chromatograph with chart recorder	**Gow Mac Instrument Company** *P. O. Box 32* *Bound Brook, NJ 08805*
Scintillation spectrometer Horizon II microcomputer	**North Star Computers, Inc.** *14440 Catalina St.* *San Leandro, CA 94577*
ADM3A video terminal	**Lear-Siegler, Inc.** *714 North Brookhurst St.* *Anaheim, CA 92803*
Retrographic high-resolution graphics for ADM3A	**Digital Engineering, Inc.** *1787-K Tribute Road* *Sacramento, CA 95815*
NaI detector Model 2010 amplifier analyzer Model L scaler	**The Nucleus, Inc.** *Box R* *Oak Ridge, TN 37830*
Model SR255B chart recorder	**Heath Company** *Benton Harbor, MI 49022*
Model D7A AD/DA converter	**Cromemco, Inc.** *280 Bernardo Ave.* *Mountain View, CA 94040*

Users of the gamma scintillation spectrometer are chemical technology and medical laboratory technology students in their instrumental analysis courses. They operate the scintillation spectrometer both in its original manual mode and in its computer-controlled mode, and are thus able to see the sort of enhancement in instrument performance that is possible when computer control is used. Also important is that the students are able to spend more time on the chemical techniques and applications of gamma scintillation spectroscopy because the equipment is easier to use, and it takes much less fiddling on the part of the student to get it to produce usable results. This is an important point. Students benefit in two ways by using the gamma scintillation system: They learn about the advantages of using laboratory computers, and, at the same time, are able to do more *chemistry* due to the increased efficiency of the computer-controlled equipment. Using each system has become a regular part of the laboratory courses at Broome.

Some final words

Interfacing a microcomputer with external instrumentation requires skill in analog and digital electronics and computer programming in both high-level and assembly language. A sophisticated type of ADC/DAC convertor (California Data Corporation, Newbury Park, CA) now eliminates the need for much of the electronics work (interface hardware) done in this project. These converters contain built-in software-controlled, programmable-gain operational amplifiers that can eliminate the requirement for interface hardware. Such equipment allows interfacing the analog peripherals by simply running a two-wire pair to each piece of equipment to be connected to the computer. There is, of course, a penalty to be paid for this convenience: The ADC/DAC boards are more expensive than the Cromemco board used in this project. The cost is not prohibitive; thus it should be possible for many more individuals with a knowledge of programming but little hardware experience to do their own interfacing, using this newest type of equipment.

The era of having a computer or two in every laboratory is upon us. Now the newest computer equipment should make it possible for anyone with even a minimal software background to begin working with laboratory computer interfacing.

Information packages for the two projects described are available, each containing additional details of the project hardware and listings of the programs, at a cost of $5 per package to cover postage and handling. Make checks payable to Joseph W. Long, Chemical Engineering Technology Department, Broome Community College, Box 1017, Binghamton, NY 13902 and specify either the Data Analyzer package or Scintillation Spectrometer package. Copies of the programs, on disk, are also available at no charge (North Star single density). You must supply the disk and include SASE for return of the disk.

Implementing the Advanced Features of CP/M Plus: Part 2

by Bruce R. Ratoff

In the February issue, I discussed some of the details of bringing up a CP/M Plus system with memory management. Now we will look at some additional routines that may be added to your CP/M Plus BIOS to further enhance system performance. None of these routines is required to get the system running, but each one activates an additional feature or makes the system run faster.

Date and time support

One of the most asked-for features in the new CP/M is the ability to handle date and time. BDOS calls have been provided to read and set the system date and time. For compatibility, these calls use the same function numbers and data format as MP/M. While it's nice to be able to use the date and time from your programs, the most valuable use of date and time is the ability to time-stamp your files. On each of your diskettes or hard disk drives, you may instruct CP/M Plus to record the date and time each of your files was last updated. In addition, you may also elect to record either the date and time of creation or the date and time of last access. Since most CP/M programs update a file by outright replacement, the most useful combination is probably update time and access time.

The BDOS keeps the system date and time in a group of memory locations in the System Control Block. The SCB is a special area of memory containing a number of BDOS variables. These variables may be accessed from the BIOS by declaring them in an EXTERN statement and linking the BIOS with the system module SCB.REL, which is provided on the release disk.

If your system has a clock chip somewhere, implementing the system date and time features becomes extremely easy. One of the new BIOS jump vectors is intended for a routine called TIME. This vector is called whenever the BDOS wants to either read or change the date and time. On entry to your TIME routine, if the C register contains a 0, the BDOS is about to read the date and time. Your routine should read your clock hardware and store the date and time into the appropriate slots in the SCB. If, on entry to the TIME routine, the C register contains an FF (hex), the BDOS has just changed the date and time. In this case, your routine should use the date and time in the SCB to update the clock hardware.

Even if your system does not contain specific timekeeping hardware, you can still have date and time support if your hardware can provide some kind of periodic interrupt. The most common implementation would be to use a counter/timer chip such as the Intel 8253 or Zilog Z80-CTC. Another common method is to pick off the unfiltered 60 Hz from your power supply and derive an interrupt from that. If your system contains video-generation hardware, you may also be able to obtain an interrupt from the vertical sync circuit, which is also usually around 60 Hz.

Whatever the implementation, the object is to generate an interrupt at some regular interval. You then must write an interrupt handler that counts up the interrupts and updates the time and date fields once per second. If your hardware can be programmed for one interrupt per second, this becomes very straightforward. If the only interrupt rates available are somewhat faster (and this is usually the case), you must include an extra counter in your interrupt routine.

The time-of-day routine used in my BIOS is shown at the end of this article.

Multisector disk I/O

One of the new BDOS features of CP/M Plus allows an application program to read or write more than one 128-byte disk record at a time with a single BDOS call. A new BDOS function, "Set Multisector Count," may be used by an application program to set the number of records read or written by each BDOS call to any number between 1 and 128. This means that an entire extent can be transferred in a single operaiton. The CCP and PIP both make heavy use of this function to speed up program loading and file copying.

Several changes in the BDOS behavior occur when an application uses the Multisector I/O feature. In processing a multisector read or write, the BDOS will attempt to pick out the sections of the file which are contiguous on the disk. Whenever one of these sections encompasses one or more entire physical (nondeblocked) sectors, the entire deblocking and buffering scheme is bypassed and the data is transferred from the disk directly into the TPA. This speeds up the transfer by eliminating the time required to copy each sector into or out of a deblocking buffer. This portion of the multisector transfer logic is handled entirely within the BDOS, requiring no special code in the BIOS.

You may provide an additional speed increase in multisector disk I/O by adding code to your BIOS to read and write multiple sectors at a time. Before starting the transfer of each contiguous section of a multisector transfer, the BDOS makes a call to the MULTIO entry point of the BIOS. This new entry point informs the BIOS that the next "n" disk reads or writes are to a logically contiguous area of the disk. The BIOS can make use of this information on the next read or write call to transfer the total number of sectors requested.

There is one major "gotcha" in the MULTIO

Bruce R. Ratoff, 26 Broad St., Cranford, NJ 07016; (201) 272-1793

logic. In making a multisector BIOS call, the BDOS does not take into account your sector translation ("skew") logic. Therefore, you can only do the disk operation correctly on the first call if your BIOS does not use a software skew of the disk sector numbers. How then can you take advantage of MULTIO on a skewed disk? By performing a bit of additional trickery.

It is significant to observe that the BDOS will still make the full set of disk I/O (Set Track, Sector, Set DMA, etc.) for each sector of a multiple transfer. Note also that the BDOS does not really care which of these calls performs the actual disk I/O, as long as all of the sectors have been transferred by the time the "nth" read or write call is completed. If you are on a nonskewed disk, it is probably simplest to do the entire data transfer on the first of these calls, and ignore the next "n-1" read or write calls. If you are on a skewed disk, you can store the track numbers, sector numbers, and DMA addresses in a table, and perform all of the disk I/O on the final call. Various other schemes are possible, and the best advice here is to do the best you can on your particular hardware to take advantage of the added information passed by the MULTIO call.

Nondisk I/O enhancements

You may recall that previous versions of CP/M have often made reference to something called the "I/O byte." This dates back to the original Intel development system for which CP/M was originally created. The I/O byte was a simple means of taking up to four *physical* devices, such as a Teletype, a CRT terminal, paper tape equipment, etc., and selecting which one to use for each of CP/M's five *logical* devices: Console Input, Console Output, Auxiliary Input ("Reader"), Auxiliary Output ("Punch"), and List Output. Under this scheme, there was a one-out-of-four choice for each logical device, although the four physical devices for one logical device did not necessarily have to be the same as for another logical device.

In CP/M Plus, the I/O byte has been replaced by five 16-bit words in the SCB, known as the Redirection Vectors. There is one Redirection Vector for each logical device. The upper 12 bits of each Redirection Vector are used to select up to 12 physical devices. Unlike the previous scheme, it is assumed that the same 12 physical choices will be available for each logical device. The lower four bits of each Redirection Vector are reserved for internal use by the BDOS. Setting any of the upper 12 bits in one of the Redirection Vectors means that the corresponding physical device should be used as that logical device.

This new scheme has several interesting implications. For one thing, a broader range of choices now exists for each logical device assignment, since 12 choices are possible instead of four. Also, it is possible under this new scheme to have more than one physical device associated with a logical device at the same time. This allows you to do such things as sending a listing to more than one printer, or simultaneously to the printer and the console. You might assign more than one device as the console, enabling you to operate your system from more than one location, or to let somebody watch what you're doing on another display. Other possibilities that come to mind are multiplayer games and operating your system via modem.

The Redirection Vectors reside in the System Control Block (SCB), but the code to handle them must be provided in your BIOS. Two new BIOS routines, and some changes to your console, auxilliary input, auxilliary output, and printer routines are required.

The first new routine required is called DEVTBL. This routine must return the address of a table containing the names and attributes of each physical device in your system. Each physical device is given a name of up to six characters. The attributes stored in the device table include whether the device can do input or output, whether the device is serial or parallel, its baud rate, whether the baud rate can be changed, and whether XON/XOFF protocol should be recognized. You must create this table within the resident portion of your BIOS, and fill it with the names and attributes of your hardware.

The other new routine is called DEVINI. This routine is called with a device number, corresponding to the relative position of one of your system's physical devices in the device table described above. DEVINI must re-initialize the indicated device according to the parameters set in the device table. Normally, this routine will be called by the CP/M Plus program DEVICE, to indicate that it has modified the indicated device's attributes. You may also modify the device table and call DEVINI from your applications programs.

Note that DEVICE is the only program provided with the system that uses DEVTBL and DEVINI. The BDOS itself never calls these routines or references the device table. It is therefore entirely up to you whether or not to implement this feature.

Once you have created a device table and provided the DEVTBL and DEVINI routines, you must modify all your character I/O routines to use the Redirection Vectors. The routines for each logical device must pick up the corresponding vector, scan it for all the "1" bits, and call each physical I/O routine whose bit is set. This is not as tedious as it sounds, since most of the code will probably be common to all logical devices. The only differences will be in which Redirection Vector is used, and whether an input or output routine is called.

Goodbye, Control-C

This month's final item is a no-risk way to eliminate the need to type control-C when you change diskettes. This applies if your diskette drives have a way of signaling that the door has been opened. Most 8″ and some 5″ drives have an optional signal called "Disk change" that performs this function. If you have a way of reading this signal, you may use it to tell the BDOS when to check for a disk change.

There is a new field in the Disk Parameter Headers called the Media Flag. There is also a Media Flag in the System Control Block. If you can detect the Disk Change signal from your drives, you should set the Media Flag in the DPH of the affected drive to FF hex. You also must set the Media Flag in the SCB to FF hex, since this is what tells the BDOS to look at the DPH media flags. In order to be truly useful, you must set the

flags prior to the next disk access. Therefore, the Disk Change logic should be independent of your actual disk I/O routines. It could be made an interrupt routine, or you might test it while waiting for console input.

On the next disk access after the Media Flags have been set, the BDOS will look at the directory of the indicated drive to see if there has been an acutal disk change, and will log in the new disk if a change has occurred. While the BDOS would normally have performed this check at the next directory access, the media flag logic protects you against the possibility of any nondirectory I/O prior to the next directory access occurring on the wrong diskette.

Conclusion

Through my personal contact with other CP/M users, I have seen a great deal of interest in CP/M Plus and heard a great number of questions. It is my intention to answer as many of these as I can through *Microsystems*. If you have a comment or question that you would like to see answered in print, please write to me in care of the magazine, and I will do my best to provide an answer.

Erratum

On page 26 of our February 1983 issue, Bruce Ratoff's telephone number had two digits transposed. The correct number is (201) 272-1793. Our sincere apologies for any inconvenience caused by this error.

```
;
;CP/M Plus BIOS routine to keep time of day from 50 millisecond
;timer interrupt.
;
        EXTERN  @SEC,@MIN,@HOUR,@DATE

RTCINT:
        OUT     RTCRST          ; Clear clock interrupt request

        SHLD    SAVHL
        POP     H
        CALL    INT$SAVE        ; Save all registers

        LDA     MILSEC          ; Count up milliseconds
        ADI     5               ; (Interrupts are every 50 ms.)
        CPI     100
        JNC     NEWSEC          ; Go do real work if a second's gone by
PUTMIL:
        STA     MILSEC          ; Otherwise just save milliseconds
        RET                     ; and exit.
NEWSEC:
        LDA     @SEC            ; Increment seconds
        ADI     1
        DAA
        CPI     60H             ; Check for a full minute
        JZ      NEWMIN
PUTSEC:
        STA     @SEC            ; Store new seconds
        SUB     A
        JMP     PUTMIL          ; Clear milliseconds
NEWMIN:
        LDA     @MIN            ; Increment minutes
        ADI     1
        DAA
        CPI     60H             ; Check for hour
        JZ      NEWHOUR
PUTMIN:
        STA     @MIN            ; Store new minutes
        SUB     A
        JMP     PUTSEC          ; Clear seconds
NEWHOUR:
        LDA     @HOUR           ; Bump hours
        ADI     1
        DAA
        CPI     24H             ; Check for day crossing
        JZ      NEWDAY
PUTHOUR:
        STA     @HOUR           ; Update hour
        SUB     A
        JMP     PUTMIN          ; And clear minutes
NEWDAY:
        LHLD    @DATE
        INX     H               ; Bump days
        SHLD    @DATE
        SUB     A               ; And clear hours
        JMP     PUTHOUR

; stack and register save/restore routines
INT$SAVE:                               ; interrupt stack saver routine
        SHLD    SAVRET
        POP     H
        SHLD    RETCALL+1               ; store for returning
        PUSH    PSW
        LXI     H,0
        DAD     SP                      ; old stack pointer in HL
        LXI     SP,STACK                ; set new stack
        PUSH    B
        PUSH    D
        PUSH    H
        LXI     H,INT$REST              ; push restore address on stack
        PUSH    H
RETCALL JMP     0                       ; return to caller

MILSEC  DB      0                       ; millisecond storage
SAVHL   DW      0                       ; HL storage
SAVRET  DW      0                       ; ret value storage
INTFL   DB      0                       ; interrupt flag
        DS      24
STACK   EQU     $                       ; interrupt stack

INT$REST:                               ; restore previosly saved status
        POP     H
        POP     D
        POP     B
        SPHL                            ; restore old stack pointer
        mvi     a,7
        out     0c4h                    ; enable IMSAI PIC-8
        POP     PSW
        LHLD    SAVRET
        PUSH    H
        LHLD    SAVHL
        EI
        RET
```

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CIRCLE 48 ON READER SERVICE CARD

The Pickles & Trout IEEE-488/IEEE-696 Bus Converter

by Richard S. Newrock

Microcomputers are rapidly finding their way into the laboratory for numerical analysis, data reduction, experimental control and data taking. For the last two, there are three options: direct I/O via parallel ports (and occasionally, serial ports), analog I/O via the appropriate A/D and D/A converters, and the IEEE-488 instrument bus (GPIB or HPIB). This last is a most important method, as most state-of-the-art test and measurement instruments come with a 488-bus interface. If microcomputers are to be useful in the laboratory, they must be able to control such instruments. When I decided to switch my laboratory from minis to micros, the availability of a good S-100/488 bus converter was an important factor. This article reviews the bus converter I purchased, the Pickles & Trout 488 Bus Interface (P&T-488).

This review discusses the hardware and software aspects of the P&T-488. My conclusions can be summarized briefly: the P&T-488 bus converter is an excellent product. The hardware is well-designed and executed. It is simple to program in high-level languages or in assembler (when bus speed is important), and it comes with a useful and complete software package. The driver software, while slow, is good for most purposes, and adequate information is provided to help you write faster routines. Many good examples of software are displayed. Unfortunately, as is often the case in this field, the manual is poor.

In addition, and of great importance to me, the software driver routines are relocatable; they can be called from high-level languages. In particular, I can call them from Fortran programs, a considerable timesaver since nearly all of my research software is written in Fortran, as are the libraries of scientific subroutines I use.

The board is available for $450, directly from Pickles & Trout, P.O. Box 1206, Goleta, CA 93116. The price includes the board, software, test plug, and a ribbon cable with a 488 metric connector. The 488 connector is mounted on the rear panel of the computer and the ribbon cable is run between it and the board; a 488-bus cable is not supplied.

The hardware

The P&T-488 board is glass-epoxy and is solder-masked with silk-screened labels. Each component, the jumper area (for interrupts), and the address switch is clearly labeled. The soldering is cleanly done and all components are carefully mounted. Sockets are provided for the ICs. The ribbon cable connector on the board is of good quality; it is keyed and has connector ejectors. The only thing I didn't like was the 488 connector. The one provided looks as if it will not stand up to repeated use. The manufacturer assures me that it will, and that they tested several other types and found them wanting.

The board power supply, which consists of a single five-volt regular, looks to be more than sufficient. There is an adequate number of 0.1μF bypass capacitors distributed about the board to suppress switching transients.

The P&T-488 can generate interrupts, and provision has been made (via jumpers) to select NMI, pINT, or one of the vectored interrupt lines. Eight conditions can cause an interrupt: a change on any one of the three handshake lines (DAV, NRFD, and NDAC), four of the bus managment lines (IFC, ATN, SRQ, and REN) or POC/RESET on the S-100 bus. They are "or-ed" onto the selected line. Note that it is not necessary to use interrupts to operate the P&T-488.

Pickles & Trout does not make any claims about the compatibility of their board with the IEEE-696 standard; indeed, the pin labels on their schematic are the old S-100 names. To make certain it is compatible with the standard, I checked each pin assignment; there were no conflicts. The board does not use any of the undefined (NDEF) or reserved (RFU) lines, and there are no problems with the new ground lines. The P&T-488 does not support 16-bit data transfers (SIXTN* and SXTRQ* are not implemented), but that is unimportant for a device that uses ASCII codes. It is only addressable at the first 256 I/O ports, and, in that respect, does not meet the IEEE standard, but that is not critical.

Insofar as the IEEE-488 standard is concerned, extensive checks weren't necessary. The P&T-488 works at the data transfer rates for which it was designed, so we can assume that the bus timing, pin assignments, etc., are correct. I did check the line drivers; they are open collector, as they should be for a fully operational controller.

Registers. The user accesses the bus through four 8-bit registers that appear at four consecutive I/O addresses. The port is addressed, via a DIP switch, to any location which is an integral multiple of four (0,4,8, . . .). The board comes addressed at 7C and the software provided expects that address. A special routine allows you to use the software with a different board address. The use of these registers is straightforward, and they make the P&T-488 easy to use. They are worth further discussion.

Register 3, a write-only register, stores the parallel poll response byte. The CPU inserts a byte into this register to be placed on the data lines in response to such a poll.

Register 2 is the data line register; it is a read/write register connected to the 488-bus data lines. To read the data lines, the CPU reads the byte in

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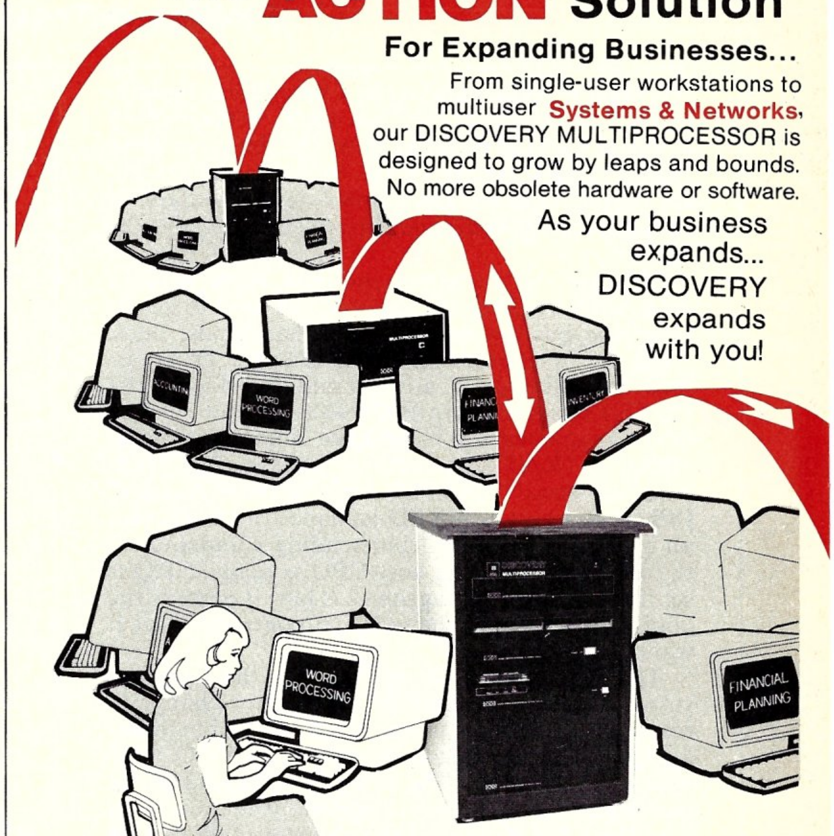

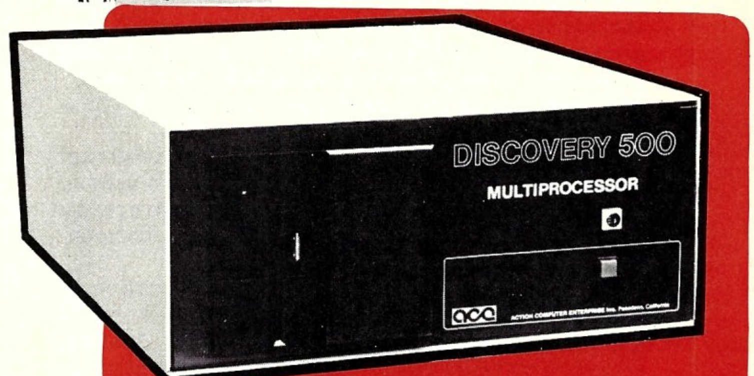

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CIRCLE 183 ON READER SERVICE CARD

this register. It can also write a byte to this register to be transferred to the data lines. Whenever an external controller takes over the bus, or when POC/RESET occurs on the S-100 bus, flags are set that disable the P&T-488's output buffers. If so, whatever is contained in register 2 cannot be output.

Register 1, the command line register, is a read/write register that allows the user to set or sense the bus management and handshake lines. Again, if an external controller is active, the interface is inhibited. If an external interface clear (XIFC) is sensed, the P&T-488 will not set any bus management or handshake lines. If external attention (XATN) is set, no lines except "not-ready-for-data" (NRFD) and "service request" (SRQ) can be set. NRFD is made true to prevent an external controller from sending commands to the P&T-488 until its host CPU is ready. SRQ is set if the SRQ bit in register 2 is low; it permits the host CPU to signal the external controller that it wants service.

The read section of register 0 is the interrupt status register. The bits in this register change in response to changes in the state of the bus management and handshake lines, and to POC. This byte is used by the CPU to monitor bus status. In particular, since the board uses only one interrupt line, the CPU must read this register to determine the cause of the interrupt. Two of the status bits are the flags XATN and XIFC. The first of these flags, mentioned above, is set whenever an external controller takes over the bus; the second whenever an external controller issues an IFC.

The write section of register 0 is for interrupt reset. The upper six bits of this register are used to reset the status bits. Bit 1 is used to instruct the controller to be a listener or a talker. Bit zero enables or disables the interrupt.

To someone familiar with 488-bus operation, it should be clear that these registers are all that is needed to control the bus: register three is to respond to parallel polls; register two is to send or receive data; register one is to assert the handshake and bus management lines; and register zero is for status. Pickles & Trout provides examples of assembly language routines for source handshaking, acceptor handshaking, initialization, etc. The best way to understand the operation of the bus and the use of the registers is to examine these routines carefully. In addition, they are an excellent starting place for writing your own drivers.

Since Pickles & Trout supplies driver subroutines as part of the P&T-488 package, why would you want to write your own drivers? The answer is simple: speed. Pickles & Trout note that their software, with an 8080 CPU running at 2MHz with no memory wait states, will transfer data at 3KB/sec. This is rather slow. One reason is that the software continually checks for things that may be nonexistent (or unnecessary) in your system. For example, the software checks for the presence of another controller, for POC on the S-100 bus, for time limits on the handshake cycle, etc. Eliminating these checks (and others) by writing your own software will speed up the data transfer rate considerably. I have not measured the increase, but, according to the manufacturer, the maximum transfer rate should be about 9KB/sec with a 2MHz 8080 (and, perhaps, 22-23KB/sec with a 5Mz 8085).

The software

The software provided by Pickles & Trout can be divided into four parts. The package includes a routine to test bus operation; MSOFT, a package of Basic subroutines to operate the bus; three utility programs; and the aforementioned assembler source and acceptor handshake routines. I found all of it useful, if only for informational purposes.

Test program. The function-test program is a nice touch; I wish more manufacturers would supply such a routine. The program performs seven tests of the board and cable, which allow the purchaser to check the P&T-488 when it is received and at any time thereafter. When planning a new experiment, I often need to order new equipment; naturally, deliveries aren't simultaneous. I have often been in the position of having an instrument's warranty period elapse while waiting for something necessary to test it. The self-test program alleviates this for the P&T-488.

The first four tests are performed with nothing connected to the bus; with the last three a special test plug is used. The first four are simple and check the registers. They consist of writing a byte to the appropriate register and checking the P&T-488's response. If any of these tests fail, it is reported on the system console. Upon (successful) completion of these the operator is prompted to connect the test plug, which connects the data lines to the bus management and handshake lines. This allows the cable to be tested for shorts and continuity, and allows the P&T-488 to talk to itself to test the response to external IFC and ATN.

The tests are simple to use and take little time; my P&T-488 passed with no problems. Two versions of the test are supplied, because of recent revisions to the board. Be sure to check the board serial number and use the correct test routine. The test routine assumes the factory standard address; I found it simplest to test the P&T-488 there and make address changes later.

Utilities. Three utility programs are supplied: BUSMON, 488TODSK, and DSKTO488. The latter two send data from the bus to a disk file or send a disk file over the bus. I generally analyze data as it comes in and create files in my control

The Pickles & Trout 488 is an excellent product, well designed and executed. It comes with a useful and complete software package.

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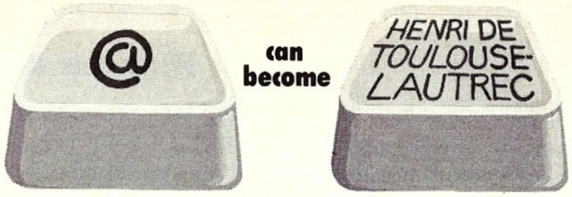

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and analysis routines. As such, I don't need these utilities and did not test them. They should be particularly useful for sending data directly to a printer or plotter, for communication between computers, and collecting large amounts of data rapidly.

BUSMON monitors and reports all bus transactions. It reports in two forms: with no special character handling and with all control codes replaced by printable characters. BUSMON stops the processing on three conditions: the occurrence of LF, CR, or on every byte. When the processing stops, the user can enter bus commands from the keyboard, restart, and observe the results of the command. All instructions sent to the controller, and all data sent or received, are displayed on the console. Messages which indicate the occurrence of XIFC, XATN, etc., changes in SRQ, POC and REN, as well as identifiers for the various addressed and universal commands, are also displayed.

I found BUSMON to be useful for troubleshooting instrumentation systems, for learning about newly purchased instruments, and for general error checking. It probably is a useful learning tool for someone new to 488-bus operation.

MSOFT. I have two software packages for the P&T-488: MSOFT, and a set of routines called "CP/M-488." The CP/M-488 package came with the bus when I ordered it. When used, it alters CP/M's I/O routines to allow the P&T-488 to substitute directly for the console keyboard and display. A software switch allows the user to determine where the I/O goes: to the normal console or to the P&T-488. I found these routines clumsy, and the instructions unclear. When I called Pickles & Trout to get some assistance, they told me about the new MSOFT routines; they can be purchased for about $50. You now have a choice when you purchase the package; make sure you get MSOFT, as it is significantly better and easier to use than CP/M-488.

MSOFT is an interface program between P&T-488 and Microsoft Basic. It consists of two parts: MSOFT.COM and MSOFT.REL. The .COM file is used with interpreter basic; the .REL file, a library of relocatable subroutines, is meant to be used with compiled languages. A typical applications program has two parts: a Basic (or other high level language) program plus MSOFT. In a compiled language, the MSOFT routines are inserted at link-time; in interpreter Basic they are called before MBasic (i.e., at the prompt, one enters MSOFT MBASIC MYPROG.BAS).

The MSOFT package defines 11 communications variables and 13 communication functions, four set-up functions and one configuration function.

The variables are for communication to and from MSOFT. The user can choose any names he wishes, but he must tell MSOFT what they are. Several of these variables have obvious uses: the INPUT and the OUTPUT strings; the string LENGTH, POLL RESPONSE and BUS STATUS integers; and the input and output ECHO bytes.

The user should be aware of an important point concerning MSOFT's output. MSOFT always writes data into the same buffer. If the user wishes to save the data in that buffer he must move it before asking MSOFT to get more. This is a subtle point. The MSOFT routine LSTN(A$) tells the P&T-488 to become a listener. Data is read from the bus and stored in the buffer; the string A$ points to that buffer. That is, the string descriptor (described below) of A$ contains the address of MSOFT's buffer. If you now tell MSOFT to get more data, perhaps with LSTN(B$), the string descriptor for B$ will also contain the address of MSOFT's buffer, i.e., both string descriptors now point to the same buffer and therefore both strings contain the same data; whatever was contained in the buffer after the first LSTN command has been lost. To save the data you must move the string between calls to LSTN. For example, between calls to LSTN, use the Basic statement S$=A$. It will store the contents of MSOFT's buffer (pointed to by A$'s string descriptor) in a new buffer, pointed to by S$'s string descriptor.

Three of the variables have special uses:

ERROR CODE. This integer variable indicates if errors occurred during a bus operation. Each bit represents a different type of error.

TIMEOUT. This is the amount of time within which a handshake must occur, or an error will result. TIMEOUT can take any value between 0 and 255; if it equals 255, no check is made. It is important that a 488-bus operating system have a time limit, particularly in systems where the controlled instruments can be many meters away, and under local control. According to Pickles & Trout, with a 2MHz system clock, TIMEOUT=254 corresponds to about 6.5 seconds. This (maximum) time is much too short, more so with a 5MHz processor. Initializing some digital plotters, for example, can take 8-10 seconds.

EOT and EOS. These variables allow the user to set string terminators and other string parameters. This is a necessary feature; many older instruments do not follow the new standard for communications over the 488-bus, IEEE 728-1982.

The communications functions are used to operate the bus. There are three main communication routines which allow the user to control the bus, to listen and to talk. Two routines are provided for each of these functions. The first clears the error byte, performs the function, and then updates the

The CP/M-488 routines are clumsy and the instructions unclear. The MSOFT interface package, now available, is significantly better and easier to use.

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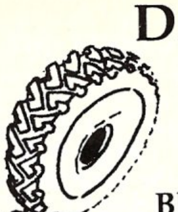

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error byte. The second performs the function and updates the error byte. The difference is quite important as it gives the user the option of calling a series of subroutines and checking for errors after the series is complete. This speeds up bus transactions considerably. The other communication functions are simpler. Some of them allow the user to reset the bus, clear the interface, enable or disable remote, and update the bus status variable. Others are for parallel and serial polls.

There are four set-up functions used to initialize MSOFT; they tell it the variable and function names. One, SETUP, is only used with interpreter Basic, where you must inform MSOFT.COM of the names of each the communication functions. This is not necessary in compiled languages, where the linker inserts relocatable subroutines where they are needed. The other set-up routines pass variable names to MSOFT, are needed by both MSOFT versions, and must be called at the beginning of all application programs.

The two most important set-up functions are IOSET and PROTCL. IOSET tells MSOFT the name you've chosen for the error code, the timeout value, the poll response byte and the bus status byte. PROTCL sets up the data transfer protocol, including the string lengths and string terminators. These variables may have to be initialized, depending on the language used. (Remember, Basic initializes all variables to zero; other languages may not.) In any case, IOSET and PROTC initialize time limit and string length to 254.

The last set-up function, ECHO, tells MSOFT the name of the byte which determines if bus I/O is echoed on the console. It defaults to no echo.

The last routine is the configuration function. It is called at the beginning of each program if MSOFT has to be informed of a change in the P&T-488's address (from 7C).

Sample programs. Pickles & Trout provides several sample programs. Four of these programs (BISAMPL.BAS, BCSAMPL.BAS, MTSAMPLE.PAS and FSAMPLE.FOR) allow the user to connect any 488-controllable instrument to the bus and play with it. They are menu driven: the user is asked what bus function he would like to perform and is prompted for the necessary parameters. I found these programs to be very useful. If you are unfamiliar with the 488-bus and its commands, these routines will allow you to play with the system, controlling one or more instruments, sending commands and collecting data, until you gain familiarity with the operation of the bus. The programs allow you to try a new instrument, testing it and learning about its programming quirks. Finally, and perhaps most important, the programs present many examples of the software necessary to operate the P&T-488. Unfortunately, the only place much of this information is presented is in these programs.

In addition to the four sample programs, Pickles & Trout provides examples of application pro-

grams written in interpreter and compiler Basic, Fortran, assembler, Pascal and C. These programs, which control a Hewlett-Packard 59309 digital clock, also contain many valuable examples of the use of MSOFT's functions. Although they were very informative, I think they would be even more useful if they referred to a more commonly available 488 instrument, such as a digital voltmeter.

Parameter conversion. The MSOFT communication functions are relocatable subroutines. Since MSOFT is designed to interface to Microsoft Basic, it passes parameters to such subroutines in the same manner as Basic: CALL SUBPROG(P1,P2,.....Pn) passes the parameters P1......Pn. However, Basic passes parameters differently from other high-level languages. This means that an assembler program is necessary to convert from Basic's parameter passing convention to whatever convention your language requires.

One important difficulty occurs with strings. Basic stores strings in two parts, the string itself and the string descriptor. This last, a three-byte block, contains the number of characters in the string in the first byte and the address of the first character in the string in the second and last bytes. When Basic passes a string, it passes the memory address of the string descriptor. The called subprogram must look into that descriptor block to find the string address.

MSOFT works the same way. When a non-Basic program wants to pass a string to MSOFT, it must first convert the string to Basic's format; i.e., a string descriptor must be created. Similarly, when MSOFT returns a string (e.g., data) it must be converted to the form required by the calling program. The manufacturer provides several routines to perform and illustrate these conversions.

For assembly language programmers, Pickles & Trout wrote CLOCK.MAC. It illustrates how the addresses of passed parameters (strings and integers) are to be placed in the various registers and tables for MSOFT's use. For users of PASCAL/MT+, MT488.MAC is supplied to perform the parameter passing conversion. PASCAL passes addresses on the stack and expects the called routine to remove them from the stack. MT488 does this and places the addresses into the appropriate registers and tables for MSOFT. Several assembly language programs are provided for users of Fortran: STRIN.MAC, STRXFR.FOR and STRSET.FOR. STRIN collects strings from the keyboard and creates the string descriptor for BASIC. STRXFR copies strings from MSOFT's input buffer into a Fortran array. STRSET generates a string descriptor block for a Fortran array. For C a routine is provided to create a string descriptor.

I did not attempt to test all of the sample programs, but looked only at the ones in interpreter and compiler Basic, assembler, and Fortran. All of

the routines worked well. (In Fortran, I did not use STRIN.MAC, preferring to use a canned string-handling program The STRING BIT.) I wrote several application programs to control various instruments in my laboratory and found it to be a straightforward process. The software provided by Pickles & Trout works, and it works well.

The manual

Finally, a few comments about the manual. It is poorly written and extracting information from it is difficult. There are four major problems.

First, it is "schizophrenic." The authors obviously cannot decide on their audience. Very detailed explanations, suitable for the experienced user, are intermixed with material clearly of value only to the novice. While there is nothing wrong with writing a manual for both audiences, it must be done carefully; the advanced material must be well separated from the elementary and clearly identified, or the novice will get lost quickly.

I think that some of the simple material is just plain silly: for example, an entire page is devoted to a table showing all possible settings of the address switches. I would imagine that if a user is unable to address the P&T-488 without this table, he is probably unable to use it at all. However, Pickles & Trout tell me that they received many telephone calls regarding addressing before they included that table; now they receive none. They conclude that such "silly" details are of great help to many users. Perhaps they are correct; after all, experience is the best teacher. But such details belong in an appendix.

Second, the authors have difficulty in going between the general and the specific. They often start a general discussion of some aspect of the bus only to get bogged down in specific, nonilluminating details. For instance, in the middle of a description of uniline and multiline commands, using serial and parallel polls as examples, they go off on a tangent describing parallel poll instrument assignments. While this is important, it is completely out of place, and the reader quickly loses his train of thought about uniline and multiline commands.

Third, many of the important features and functions of the IEEE-488 bus are either inadequately described or not described at all. Important instructions and comments about a particular function are often located in three or four different places in the manual. One has to search to get a complete description of a function or to get a "recipe" for its use. Sometimes the information is in the text and sometimes it is buried in programs. This is exacerbated by the lack of an index. Surely, if you are going to scatter important information about in the text, an index should be provided to help you find it. I spent an inordinate amount of time searching for remarks I recalled reading, but couldn't locate. It would be best if each and every 488-bus command and function were individually

Pickles & Trout continued . . .

described with notations as to how to best implement the operation in software.

Fourth, and of less importance, the P&T-488 is meant to be used by microcomputer owners, a group that (probably) has little previous 488 experience. Therefore, a (reasonably) complete description of the bus should be given. An attempt to do so is made, but more care and detail are needed. A glossary of bus terms (taken from the IEEE standards document) is provided, but it is terse to the point where an inexperienced user will find it worthless.

Miscellaneous

Finally, there are two miscellaneous items:

—An interesting section of the manual contains a discussion of various "quirks, oddities and gotcha's." You should be aware of these when programming. Look here when your "bugfree" software crashes.

—I contacted the Pickles & Trout people several times while trying to get their software running; they were unfailingly polite and always helpful.

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The "Standard" CP/M-86 Hardware System in the Lab

Bringing up CP/M-86 on an Intel single-board computer system interfaced to a Summagraphics Digitizer

by Ralph L. Place and Kirk A. Bailey

CP/M-86, as distributed by Digital Research, Inc., comes with a bootstrap program and BIOS specifically written for a hardware system consisting of the following components:

—Intel iSBC 86/12A single-board computer
—Intel iSBC 204 single-density floppy disk controller
—dual Shugart 800/801 disk drives
—a National BLC 8538 I/O board
—a CRT terminal
—a TI 810 printer
—at least 64K of RAM.

This is a system which operates on an Intel Multibus and offers considerable potential and expansion capability. Several years ago, shortly after Intel first announced the availability of the 86/12 board (the first version didn't have the "A" designation), we decided to build a system around this board for use as a data acquisition computer in the department's particle physics laboratory. At that time there was essentially no software available for an 8086-based system outside some Intel development software, so we expected to have to write everything—including a rudimentary operating system. Fortunately for us, by the time all the hardware actually was delivered, Digital Research had announced that CP/M-86 was available for this system, and Microsoft announced the availability of Basic-86.We concentrated our efforts on getting the system up and going.

Bringing up the system

Bringing the system up was, in principle, not difficult. However, a number of hardware problems complicated the process, especially since we were working with (to us) new and unfamiliar hardware on an unfamiliar bus. We had experience with 8-bit machines on the S-100 bus, but had had no previous experience with 16-bit machines of any kind, nor were we familiar with the Multibus. Additionally, a power supply problem zapped several ICs, and as a result considerable time was spent examining the system with a logic analyzer.

Leaving these "minor" problems aside, let's take a closer look at the hardware itself—specifically, the 86/12A board, since it is the heart of the system.

The 86/12A board is a single-board computer that plugs into one Multibus slot. The Multibus furnishes power to the board (+5V, −5V, and +12V, all regulated) and provides a 16-bit-wide data bus over which data is transferred to/from off-board memory and ports. A 20-bit-wide address path allows direct access to the entire 1MB address space of the 8086. Depending on the particular instructions being executed, an entire 16-bit word can be transferred in a single access. Single-byte transfers are also supported. Additionally, there are signals for bus requests, priority signal and interrupts, among others. In all, there are 86 pins on the Multibus. The 86/12A board itself is based on a 5MHz 8086 and includes 32K of on-board RAM, a serial RS-232C port, sockets for up to 16K of ROM, an interrupt controller that can handle up to eight interrupt sources, a programmable interval timer, and 24 programmable parallel I/O lines. For operation with CP/M-86, these on-board capabilities must be augmented with the other hardware previously listed.

In order to get CP/M-86 up on the system, we first took steps to burn-in the boot program into 2716 EPROMS. At the time we ordered the board, we also ordered a Monitor program from Intel that came in four 2716 EPROMS mounted in the ROM sockets on the 86/12A board. The monitor gave us some rudimentary capabilities for program development. This monitor program allows the user to perform some elemental functions such as examine and alter memory locations, display regions of memory, execute or single-step through programs, examine registers, and perform data I/O via ports. Additional commands allow the user to communicate with an Intel development system. Since ours was a stand-alone system, we were not interested in these latter monitor capabilities. This monitor goes by the name of the "iSBC 86/12 Interface and Execution Package," a somewhat extensive title for a small monitor program. At any rate, it was and continues to be a very valuable part of the system and has proved to be very useful in debugging.

The monitor uses up 6143 bytes of the 8K of ROM space, leaving plenty of free space for the boot program. The ROM address space on the 86/12A is located in the topmost part of the 1MB address space of the 8086, from FE000H to FFFFFH. Upon a RESET, the 8086 jumps to memory location FFFF0H in the ROM space where a jump instruction sends the CPU to the beginning of the monitor itself. The procedure expected by the monitor is for the user to press "U" twice after a RESET, setting the baud. The monitor then prompts the user for a command.

Ralph L. Place and Kirk A. Bailey, Dept. of Physics and Astronomy, Ball State University, Muncie, IN 47306

We situated the CP/M-86 boot in the lower 2K of the EPROM's space with starting address (absolute) FE000H. To execute the boot, we use the monitor to set the CS (Code Segment) register to FE00H, then enter the command G to commence execution at the desired point.

Loading CP/M-86 for this system is a two-step process with the boot program loading LOADER off the first two tracks of the disk and then jumping to it. LOADER then loads CPM.SYS into memory, starting at absolute location 0400H (1K), which is just above the reserved interrupt space in RAM. The system occupies space up to an offset of 29E4H, or a total of 10,724 bytes. This resides entirely in the 32K of on-board RAM. This on-board RAM may be accessed by the 8086 at any time; i.e., on-board accesses by the CPU do not use the Multibus. Thus, whether or not another bus master other than the 8086 has control of the Multibus, this does not prevent the 8086 from accessing the on-board RAM. This RAM is of the dual-port variety and may be accessed through the Multibus by other bus masters on other boards (e.g., DMA devices) independently of the 8086. By means of user-selectable jumpers, it is possible, if so desired, to configure this on-board RAM to be accessible only by the 8086 so that it has exclusive access rights.

Although the early documentation received from Digital Research stated that CP/M-86 would run with only a total of 64K of RAM, it failed to mention that although the operating system would in fact boot up, you couldn't do anything with it; i.e., ED or PIP wouldn't work. After considerable head-scratching (we didn't know whether or not we still had hardware problems, since we had not gotten the system completely going at one time) as well as sending several communications to Digital Research (from which we received no reply about the problem), we obtained a 128K byte board, slid it into the system, and *voila!,* the problem was solved.

With regard to the I/O features of the 86/12A board, it has one RS-232C port (an Intel 8251 USART) that is initially configured by the monitor so that CP/M-86 really doesn't have to do further initialization. Connection to the port is via a 26-pin PC edge connector. Parallel I/O is controlled by an 8255 Programmable Peripheral Interface that has three 8-bit ports. As delivered, one of the ports is configured as a bidirectional port buffered using 8226 bidirectional buffers (actually the factory configuration is set by a jumper so that the port in question is by default an output port only). The other two ports of the 8255 are brought out to an array of jumper posts and four empty 14-pin IC sockets that can be user-configured. All the parallel lines are accessed by a 50-pin PC edge connector.

The rate generator/interval timer (an 8253) provides the clock signal that is input into the USART to control baud rate. Two other outputs are available that can provide real-time interrupts to the 8259A interrupt controller.

Turning our attention to the other boards of the system, the floppy disk controller board (an iSBC 204) is based on the Intel 8271 controller chip and the Intel 8257 DMA controller. There is circuitry on the board for two 8271 chips which would enable the board to control up to four drives (single sided) but the standard board comes with only one 8271 installed. The board operates in the usual way whereby the DMA controller is first loaded with the necessary information by the CPU; the CPU then sends an appropriate command or string of commands to the controller and stands aside to let the DMA process work.

Interfacing the digitizer

As an application of this system, we can look at the way we have it connected to a 36" x 48" Summagraphics digitizer (Summagrid). This system is used in the laboratory to analyze photographic material ranging from bubble-chamber photographs of high-energy particle collisions to geological maps for research on archeoastronomy.

The Summagrid converts *x-y* postions on its surface to two binary numbers, one proportional to the *x*-position, the other proportional to the *y*-position. This binary data is output from the Summagrid through its controller in either a serial or parallel form. We chose to accept the data in parallel form and input it into the 86/12A through the 50-pin edge connector parallel I/O port. In detail, the parallel I/O is controlled on the 86/12A board by the 8255 which has three 8-bit ports, labelled A, B, and C in the Intel documentation for the 8255A and addressed at port addresses C8H, CAH, and CCH, respectively, on the 86/12A. As mentioned previously, Port A is factory-configured as an output port that we changed to an input port by changing the jumper to tie the DIEN pin to +5V instead of ground. This port accepted the 8-bit parallel data from the Summagrid. Port B has no buffers in the sockets provided as it comes from the factory, so we installed 7408s as buffer/drivers to let this port serve as an output port to send 8-bit commands to the Summagrid controller. Although the 8255A can be set up in a mode where it automatically furnishes handshaking signals, one of the signals (IBF from the 8255A) would have required an inverter to provide an active-low signal. Because of this and because this was also partly a student project, we decided to use an 8255A mode where we supplied the handshaking through software so that we could become more familiar with the details of the handshaking process. For handshaking, we used Port C, which is divided into two 4-bit sub-ports called Port C(upper) and Port C(lower) that are individually configurable as input or outputs. We configured Port C(lower) as input and Port C(upper) as output (from the computer's view). Four signals are involved in the handshaking process:

Bringing up CP/M-86 was, in principle, not difficult. However, a number of hardware problems complicated the process.

STBO—output strobe from the 86/12A to the Summagrid controller. When low, this signals the controller that a data byte is to be read by the controller.

STBI—input strobe from controller to the 86/12A. When this goes low, it signals that a data byte is ready for input to the 86/12A from the grid.

ACKO—acknowledge signal from the controller, telling the 86/12A that the data byte has been read by the controller.

ACKI—acknowledge signal from the 86/12A to the grid controller, telling it that the data byte has been read.

These signals are connected to the upper and lower nibbles of Port C as shown below.

To set up the 8255A in the appropriate mode, we consulted the Intel Component Data Catalog and examined the various operating modes for the device. We found that Mode O sets Port A and Port C (upper) as inputs and Port B, Port C (lower) as outputs; control word #9 (91H) was the one to be used. Since the particular applications for the system do not require maximum speed but do require arithmetical manipulation, we use Basic-86 (Microsoft) rather than the 8086 assembler language for our programming. The piece of code that does the elemental setup of the 8255A and subsequent data input and conversion of the raw data into *x-y* distances in centimeters is shown in the listing at the end of this article.

Summary

In summary, we have found that this computer system, based on the Intel 86/12A single-board computer, has performed very well and has been operating in the lab for over a year with only minor problems. In the meantime, we have assembled a second computer, also using an 86/12A, but with an Intel 208 disk-controller board that allows both single- and double-density disk storage. Additionally, we have installed a modified track-buffered BIOS written along the lines of an article distributed by Digital Research. We hope in the near future to obtain a hard disk system and go to MP/M-86 to allow multiple users on the system.

7	6	5	4	3	2	1	0
STBO	X	X	ACKI	ACKO	X	X	STBI
<=== OUTPUT			===>	<=== INPUT			===>

Listing 1

```
10   ' Set 8255 to mode 0, port A and port C(lower)=input
20   '                     port B and port C(upper)=output
30   ' Control word #9.  See Intel Component Data Catalog
40   '
60   ' Input from the SUMMAGRAPHICS controller is signalled
70   ' by a 'LO' on port C, bit 0.  The I/O address for
80   ' port C is &HCC
100  '
110  ' First send the control word (&H91) to the command
120  ' port (&HCE)
130  '
140  OUT &HCE,&H91
150  '
160  'Now set bit 4 of port C 'Hi'
170  '
180  OUT &HCE,&H9
190  '
200  'Now read the button colors into an array
210  FOR I = 1 TO 5
220       READ BUTTON$(I)
230  NEXT I
240  DATA RED,WHITE,BLUE,GREEN,YELLOW
250  '
260  '**** INITIALIZATION IS COMPLETED ****
270  '
280  '****************************************************
290  ' Code to communicate with the pad
300  '
310  FOR I = 1 TO 7                       :' 7 data bytes per point
320   IF (INP(&HCC) AND 1)=1 THEN 320 :' Wait till button pushed
330   IF I=1 THEN PRINT CHR$(7)         :' Beep on first byte
340   OUT &HCE,8                        :' Request data byte
350  'Read a data byte and erase garbage
360   D(I)=(NOT INP(&HC8)) AND &H3F
370   OUT 7HCE,9                        :' Confirm byte read
380   NEXT I                            :' Repeat for all 7 bytes
390  '
400  J=D(1) AND &HF                     :' Get button color code
410  IF BUTTON$(J)="RED" THEN STOP      :' Red => end of data
420  '
430  ' The counts for X and Y are 16 bits long.  From low
440  ' order to high order bits these are as follows:
450  '    X: 1st 6 bits of 2nd byte, 1st 6 bits of 3rd byte,
460  '       low nibble of 4th byte
470  '    Y: 1st 6 bits of 5th byte, 1st 6 bits of 6th byte,
480  '       low nibble of 7th byte
490  ' Compute the number of counts:
500  X = 4096 * (D(4) AND &HF) + 64 * D(3) + D(2)
510  Y = 4096 * (D(7) AND &HF) + 64 * D(6) + D(5)
520  '
530  ' Convert the number of counts to centimeters and print
540  PRINT "X = ";X*25.4/1016,"Y = ";Y*25.4/1016
550  '
560  GOTO 310                   :' Go get the next data bytes
c
```

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CIRCLE 186 ON READER SERVICE CARD

A Garland of Utilities

by Chris Terry

Rearranging your keyboard

If you have an exotic keyboard with lots of function keys that you cannot use because the codes generated by them send your editor up the wall, or if you have a French or German daisy wheel but no corresponding keyboard, or if you want to use a DSK (Dvorak Simplified Keyboard) layout, do not despair! Help is on the way from Heritage Software. They have come up with SMARTKEY, a neat program that tucks itself away just below the CCP and allows you to redefine the codes generated by all the keys on your keyboard. It intercepts all calls to the CBIOS keyboard input routines and translates received characters into codes that you have set up in a table with the aid of the FIXKEY program.

The really nice thing is that your translation is not restricted to one character per key—when trying it out, I defined the tilde (~) as a 15-character string containing my logon and password, dialed the Xerox CP-V time-sharing system at my place of work, pressed the tilde, and Presto! I was signed on with that single keystroke. In the same way, if you have function keys that generate codes with bit 7 high, you can bypass the CP/M input routine (which forces that bit low) and use them to initiate Escape sequences such as those used by the MINCE editor.

The 18-page manual contains full, easy-to-follow instructions for defining your translation table and installing and running SMARTKEY. It is not difficult to make up several versions of SMARTKEY, each having a different translation table, and store them on the disks containing different editors so that you always strike the control keys that you are used to but generate the codes required by the editor in use. SMARTKEY reduces the size of your TPA by 1.75K, but this is a small price to pay for the convenience of not having to learn a whole new set of control codes for each editor you try out.

There's really no more to say about this one. The manual is clear and has all the information you need, and the program works like a charm. If you are trying out different keyboard hardware or layouts, or editors with differing control codes, SMARTKEY will save you a lot of time and frustration.

SMARTKEY: $60.
From: Heritage Software,
2130 S. Vermont Ave.
Los Angeles, CA 90007
(213) 737-7252.

CP/M disk utilities from Norway

Contents of the package

- DDUMP: disk review and patching utility.
- DDUP: copy utility with the capability of ignoring bad sectors encountered on the source disk and continuing to read instead of aborting.
- DTEST: two-option disk test. Option 1 is a Read-Only test for use on newly formatted disks. Option 2 writes E5 to all sectors and then performs the read test. Bad blocks found are collected into a garbage file.
- DUSER copies directory entries from one user area to another, thereby allowing several users to access the same files without the need to duplicate the files.
- UNERA restores the directory entry of a file previously erased by the ERA command.

$29.95 each program, or $125 for the set of 5.

The general picture

Programs similar to DDUMP, DDUP, and DTEST are available in the CPMUG or SIG/M public domain libraries for a total cost of $12 ($4 each for three diskettes full of other goodies). One must therefore ask what special features make the Elektrokonsult utilities worth the extra money. The answer will depend upon your experience with CP/M and your needs.

If you are a newcomer to CP/M, or running a business system with nontechnical operators, some of these utilities will soon earn their keep because of their transportability and ease of use. Only .COM files are supplied, since customization is considered unnecessary and undesirable. No installation at all is necessary, and it is claimed that the programs will run on most CP/M version 2.x systems. This is particularly valuable because some of the public-domain utilities will not run on 5¼″ disk formats or on many double-density 8″ formats. I can confirm that DDUMP and DDUP run on the following systems with no trouble and consistent results: Tarbell 8″ SD, North Star 5″ DD/SD with Morrow hard disk, and Teletek 8″ DD/SD. The programs were developed on a Zenith/Heath system running under HDOS.

These programs have what I consider to be very well-designed and friendly human interfaces. A prompt is issued for every item of data needed by the program, and in the case of commands, all of the applicable command letters are listed as a reminder. Entering H at any stage gets a Help menu showing what each command does. When numeric values are needed, you are told whether they should be decimal, hexadecimal, or ASCII (or given a choice). Warnings are issued when a command is potentially destructive. Error messages are explicit and helpful (e.g., "Error: Non-existent source disk drive!"

Documentation is well organized, clear, and includes a "First Time Through" tutorial section for each program. This is followed by a detailed description of each command, a list of the error messages, and comments on possible causes of each

Chris Terry, 324 E. 35th St., New York, NY 10016

error. I found no information gaps, and (as is usual with documents from Scandinavia and Holland), the English is excellent. There are no ambiguities, and the style is neither stiff nor overly colloquial. In addition to instructions on use, the DDUMP and DDUP manuals contain some background information on disk formats and how CP/M constructs files. Given the helpful operating prompts and warnings, supplemented by the information in the manuals, it would take an extremely stupid operator to do anything disastrous to the files that are being processed!

Comments on the individual programs

DDUMP. I happen to like this one very much, because it is so easy to use. An address "ruler" over the main sector display allows one to pinpoint an address, either in the hex portion or the ASCII portion, without laboriously counting across the row (see Figure 1). Current Drive, Tack, Sector, and Block numbers are also displayed. Logical sector numbers are used—because the program can handle so many different formats, these are more informative than the physical sector numbers found on the disk.

I have only one gripe: the ASCII portion of the display does not recognize codes with bit 7 set. Thus system or R/O .COM files show up with a file type of C.M or ..M. (See the vendor's response in the box.)

Ward Christensen's DU (SIG/M Volume 16) is without doubt a far more powerful utility than DDUMP. DU allows you, for example, both to advance and back up one sector (DDUMP only advances); you can dump the allocation bit map to the printer, or search for an ASCII string starting at the current sector, print the disk parameters, see what file is allocated to Block "n", save a sector in a temporary buffer and get it back or move it to another place, and do several other things that DDUMP does not allow. However, I find the DU command set somewhat arbitrary and difficult to remember. I use it (with much poring over the documentation) when I want to do something complex or difficult. For day-to-day usage, I find DDUMP quick, easy, and friendly.

DDUP. This utility copies an entire disk from one drive to another. It has one outstanding advantage, which I have not found in any other copy utility: You may choose whether to abort or to continue if an unreadable sector is found. If you select the "continue" option on entry, the program ignores a bad sector on the source disk, writes a few lines of asterisks (*) to the corresponding sector of the Destination disk, and then goes happily on to the next sector. Since most copy programs are forcibly aborted by a bad sector, this file recovery aid alone makes it worth the price. On the other hand, DDUP is an all-or-nothing program, and for day-to-day usage I prefer the Tarbell program and its variants, also in the public domain (CPMUG Volume 25). These give you the choice of copying system tracks only, file tracks only, or both, and also permit copying to terminate when a track containing nothing but E5 is found on the source disk.

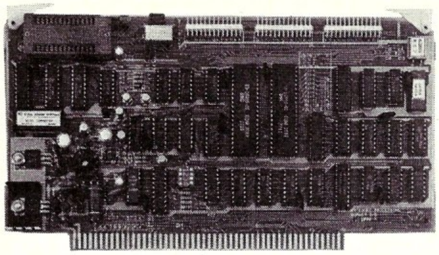
DTEST. I am not at all impressed with this program. Like FINDBAD (SIG/M Volume 16), DTEST isolates bad blocks into a garbage file and sets the file to system status so that it does not show up in the directory and will not be picked up by a PIP *.* command. Unlike FINDBAD, which nondestructively examines and checks sectors regardless of their content, DTEST absolutely requires a newly formatted disk to work on. It can be argued that this is the time to find out if the disk is bad—that is certainly true for hard errors. But soft errors are occasionally introduced by application programs, line surges, or noise, and make part of a file unreadable—and *that* is the time when FINDBAD is most valuable. I usually need to isolate the bad block immediately and continue working on the current file—I don't in the least want to swap disks around in the drives while I DDUP all the files to another disk.

A less serious (but to me extremely irritating) defect is that the Read-Only test falsely reports (and isolates) a bad block if a single byte on the disk is not E5, even if the sector itself is perfectly readable. (See the vendor's response in the box.) I see this as a design defect—at formatting time I want to know about hard errors, not stray data bytes that don't impair the readability of the disk. This defect should not occur if you opt for a Write/Read test, because the Write portion writes E5 into all sectors before the read check is performed. In my view, DTEST is neither flexible enough for superficial testing, nor thorough enough to give a real workout to an intermittently troublesome disk. It is, however, useful for quick testing of new disks containing no data.

For detailed testing, DISKTES1 (CPMUG Volume 8) is far superior. This program first fills the data areas with 00 and then does a seek from the home position to each track in turn. Then it fills the data areas successively with FF, 55, AA, and E5, checking the result of each operation, after which it does a second (and final) seek to each track. On several occasions this test has found sectors with what I can only call "sticky bits" that slipped through the cracks of FINDBAD because they were set by E5 but would not go back to 0 under normal writing conditions. It takes 6 min 47

The Elektrokonsult programs have very well-designed and friendly human interfaces . . . warnings are issued when a command is potentially destructive . . . DDUP is a copy utility that does not abort when a bad sector is encountered in the source.

THE BURNER I/O FOR THE S-100 BUS



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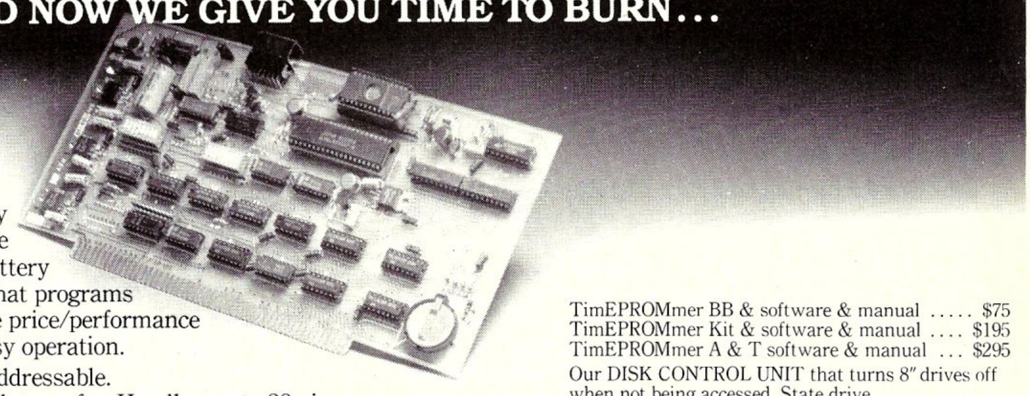

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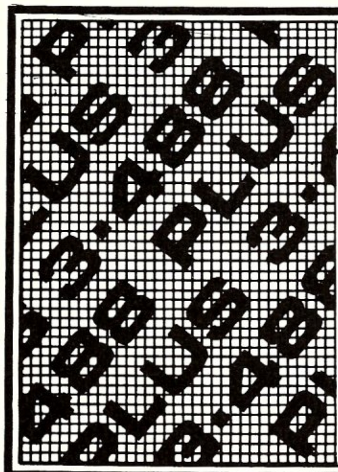
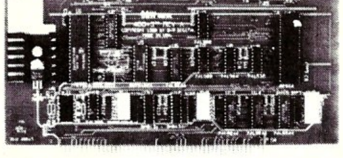
P.O. Box 81 Pittsford, NY 14534 (716) 377-0369

CIRCLE 188 ON READER SERVICE CARD



THE 488+3 IEEE 488 TO S-100 INTERFACE

IEEE-488



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CIRCLE 66 ON READER SERVICE CARD

sec to run (contrasted with the 1 min 40 sec of DTEST Read-Only, 3 min 28 sec for DTEST Write/Read, and 1 min 28 sec of FINDBAD), but it does a good job. In justice, however, I must admit that it may be hardware-dependent: I have used it on Tarbell and Thinker Toy single-density systems, under CP/M 1.4 and 2.2, but not on double-density or 5¼″ systems. The Elektrokonsult DTEST will definitely cope with any density or format.

DUSER. I can verify that this program works as stated, and I can see that it allows multiple users to make more efficient and convenient use of available disk space. However, because I have no experience with multiuser systems, I can't offer any practical comments. (See vendor's response in the box.)

UNERA. This is convenient if you are a nontechnical user who has just typed A>ERA FOOBAR.*, forgetting that FOOBAR.DAT contains test data that would be useful on other occasions. Just type A>UNERA FOOBAR.DAT and, as if by magic, the file is back in your directory—always supposing you have not written anything to that disk since the ERA command. But if you are fluent in the use of DDUMP or DU, why pay $30 to save two or three seconds in the process of changing an E5 back to a 00?

Conclusions

Elektrokonsult has come up with human interfaces that are worth study by anyone who wishes to market a program or circulate one for general use in the CPMUG and SIG/M libraries. They have (in DDUP) created a valuable file recovery aid that is not already in the public domain. It looks as though they have also been successful in creating system-independent utilities, which is a distinct advantage—a number of the public domain utilities do have unfortunate hardware or software dependencies. However, these successes in themselves do not necessarily justify the selling price. In performance I feel that DDUMP and especially DDUP are well worth anyone's consideration; DUSER and UNERA may or may not have something for you, depending on your system needs. DTEST (in my view) compares poorly with existing public domain disk tests. However, if these will not run on your system because of format incompatibilities, try DTEST; it will run on almost any format and will at least allow you to check your newly formatted disks.

From: Elektrokonsult AS
Konnerudgaten 3
3000 Drammen
NORWAY

Elektrokonsult replies:

Our disk utilities were designed to:
- be user-friendly
- work with most diskette formats and some hard disks
- be relatively well-documented so that the user may also learn something about the "inner works" of CP/M from the manuals and application notes.

In DDUMP, we deliberately did *not* zero the 8th bit so that System or R/O files would declare themselves by the period in the filetype. We see this as an advantage, not as a defect.

DTEST tests ALL tracks of the diskette, including the system tracks. We have found that some of the public domain utilities do not test the system tracks. The test for all data bytes being E5 was designed in as a check that all bytes have been correctly written by the formatter, rather than merely testing for readability. The check for E5 may be removed in a future version, allowing DTEST to be used also on diskettes containing data.

You do not have to be a in a multiuser environment to take advantage of DUSER. In a single-user system, the USER partitioning can be used to group files by topic and so help to organize your work. DUSER may not be of much use for diskettes with limited storage capacity, but for storage capacities of 500K or more, it can be very useful indeed.

The one that does everything

If you want to give away your PROM monitor and use the extra space, or to defenestrate DDT, forget FINDBAD, pitch PIP out the door, and stomp on STAT—POWER is exactly what you need. It's a steal at that modest price!

POWER is, to my way of thinking, the most versatile, friendly, convenient, and protective utility ever to hit the market. It performs most of the functions of PIP, STAT, DDT, REN, SAVE, DIR, TYPE, DUMP, FINDBAD, CKSUM and a system monitor much more conveniently than the originals do. It is a transient program executing at 100H, and occupies 12K (to 2FFFH). There are 45 different commands, including four different flavors of DUMP and TYPE and four user-definable commands for each of which an 8-byte patch area is provided. The user interface is outstandingly friendly and protective, and many of the creatures are unique to this program. Four special features make POWER easy for even completely nontechnical persons to use:

- Once loaded and running, POWER does not

POWER is one of the most versatile, friendly, convenient, and protective utilities ever to hit the market. Don't even try to get on without it.

require the system disk. Hitting ^C does *not* attempt to reboot the system; it merely updates the directory information for the current or specified drive so that you can change diskettes at any time. If you change diskettes but forget to hit ^C, POWER detects the error and prompts you for ^C before allowing you to continue the operation. Thus, you will never again get those annoying "BDOS Error: R/O" error messages. You can copy and rename and erase files to your heart's content, secure that you cannot accidentally overwrite or destroy files. Any operation that involves a disk write automatically asks for reconfirmation before performing the operation, though reconfirmation requests can, if you wish, be suppressed.

- COPY, ERA, REN, and other file operations display a directory in which a decimal number is assigned to each file. You select the files to be operated on by typing in single numbers (e.g., 5 15 31) or a range of numbers (e.g., 1-4 8-9 34-). This eliminates many, many keystrokes and greatly reduces the chances of making a mistake. No more repetitious typing of filenames and filetypes!
- As each file in a series comes up for processing, the operation and filename are displayed and the program asks for reconfirmation (Y or N) that this file is to be processed. Thus, if you do make a mistake in your entry line, the reconfirmation request allows you to correct it. Just type N, and that file is skipped. The LOG command allows you not only to select or reject reconfirmation requests, but also to show or suppress system and R/O files in the directory display, and to choose how many columns wide the directory should be.
- The documentation is excellent. The first three pages of the manual contain a command index showing command name, page number for the full description, a 2-3 line brief description, and the syntax of the command. The index is followed by a four-page section on "Getting Started with POWER," containing good examples. The rest of the manual consists of a full description of each command in name alphabetic order, with copious and helpful examples of command variants and the displays that result.

There just is not space to discuss all of the goodies in detail—You have to read the 60-page manual to grasp all the details of the power you get in this package. But I will give you the highlights, and say that after using POWER daily for three weeks I wouldn't be without it for all the tea in China!

Disk medium and file commands

- DISK reports the parameters and formatting of the diskette in the current drive.

- STAT reports free and used space on diskettes in all currently active drives.
- SIZE reports size in kilobytes, sectors used, and sectors unused, for each file selected from the numbered directory.
- SETxxx set files selected by number to SYS, R/O, R/W, or DIR status.
- CHECK computes and reports a unique checksum for each file selected by number. (A checksum for the entire diskette is handled by TEST.)
- USER and XUSER select source and destination user areas for a COPY operation on files selected by number.
- TEST nondestructively tests all sectors on the disk, segregates bad blocks into a file that is set to SYStem status, and computes a checksum for the disk.
- REN renames files selected by number from the directory. The program displays the old name and prompts you for the new name.
- ERA erases files selected by number from the directory and reports each file as it is being erased.
- RECLAIM restores files previously deleted from the current drive, after asking for reconfirmation. It will not create two files of the same name in the directory. Note that reclaimed files are automatically set to R/O status, although this fact is not mentioned in the manual. The idea is that a file that is valuable enough to reclaim should be protected against further accidental deletion. If you want to modify a reclaimed file, you must first use the SETWR command to give it Read/Write status.
- COPY copies files selected by number from any drive to any other drive, verifying the copy.
- TYPE displays an ASCII file, selected by number, exactly as entered. TYPEA displays the ASCII hex codes, 16 bytes to a line. TYPEH displays the hex code of a .COM or other file, 16 bytes to a line. TYPEX is like TYPEA but adds the printable ASCII equivalents (same format as DDT).

Monitor commands

The monitor commands are fairly standard, except that they include commands to read a disk data into memory at any address and write the data back to the disk. However, the performance of even standard commands is superior.

- DS (Display/Substitute) automatically displays the current address and the hex, decimal, binary and ASCII forms of the data

there. The default entry mode is hex, but it can at any time be changed to any of the other forms, even in mid-line.

- DUMP has the same variants as TYPE and produces similar displays.
- MOVE moves a block of data from one place to another in memory. However, the move can be in either direction, and the target address range can overlap the source address range.
- SEARCH searches a specified address range for a byte sequence. The target bytes may be ASCII, hex, or mixed, and the wild card "?" may be used to fill in an unknown portion. A target sequence may be up to 128 bytes long.
- READ and READGR bring in disk data specified by Track/Sector or by Block to any specified starting address in memory. LOAD brings in a whole file, provided there is sufficient free memory to hold it. The corresponding write commands are WRITE, WRITEGR, and SAVE.

There are other monitor commands which allow execution of a program in memory with return to POWER or to CP/M upon completion, filling a memory block with a byte, etc.

Parameter selection

The LOG command allows you to change the way certain commands work. For example, you can set the directory width, select or suppress reconfirmation requests, select or suppress read-after-write verification of disk writes, and show or suppress system files in the directory. For disk writes, if the target filename already exists, you can opt for overlaying of the previous file, creation of a backup, a reconfirmation request, or an automatic skip to the next file in the series. The options you select remain in force for your current session with POWER (unless you change them again with LOG). If you don't like the defaults selected by the vendor, you merely use LOG to set up the defaults you prefer, and then SAVE that version of POWER. Next time you use the program, your own defaults will be in effect until you change them with LOG. The LOG command tells you the last address used by POWER, so you can use POWER itself to do the save.

I could go on for hours about this utility. It's much more than a "utility" (something useful)—it becomes a necessity or an addiction, and you wonder how you ever got on without it. My heartfelt advice is: Don't even *try* to get on without it!

POWER, $149.
From: Computing! San Francisco
2519 Greenwich St.
San Francisco, CA 94123
(415) 553-0204

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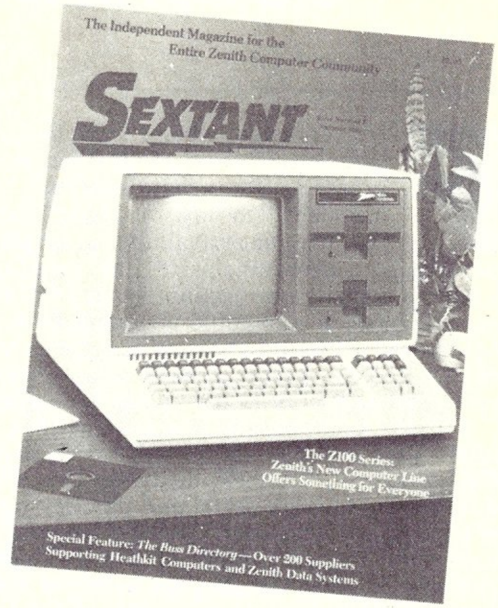

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Decisions on the Decision I

by Ernest E. Mau

Five years ago, when I went looking for a computer system to function as a word processor and general-purpose "number cruncher" in my business, there were few machines available at anything approaching an affordable price. Last summer, when I had to replace my original system—which had become obsolete and could no longer be supported or repaired—I found a variety of systems to choose from, all at affordable prices and all offering features undreamed of in my earlier computer.

Finally, I happened on a system that seemed just right—an expandable IEEE-696/S-100 bus, 4MHz Z80 CPU, 64K memory, two 8″ floppy disk drives, multiple serial and parallel input/output ports, a single-user CP/M-80 operating system, and the capability of being modified or changed to meet the ongoing needs of my enterprises. That machine was a Morrow Designs' *Decision 1*[1]. I cannot go into all the reasons I wanted an S-100 bus rather than a single-board computer, why I prefer dual floppy drives to a single floppy and a hard disk, or the rationale behind other selection criteria. It's sufficient to say that the *Decision 1* met my requirements, and that I purchased it as the new primary system for my entire consulting and writing business.

What I am going to do is report on things I encountered and the overall performance. First, however, I need to define the system in more detail. The unit I've tested, used, and generally given a thorough shakedown is the rack-mounted *Decision 1*, model R1B, which cost $4,995. That price included CP/M-80 2.2, Microsoft BASIC-80[2], and WordStar revision 3.0[3].

The standard R1B is equipped with two double-sided double-density 8″ disk drives (Shugart 850) with Morrow Designs' Disk Jockey[4] DMA Floppy Controller. It has a 64K high-speed static RAM board (Morrow calls it 65K), and a Morrow MULT I/O board with three RS-232C serial ports, one 50-pin parallel port, a real-time clock, and a programmable interrupt controller.

It's equipped with a 150-watt switching supply to power the S-100 bus and a separate linear supply to power the disk drives. The linear drive supplies are factory selected to match the drive configuration, with different supplies used for systems with one 8″ floppy, two 8″ floppies, or one floppy and one 8″ Winchester hard disk. A line filter is built into the unit for noise and surge suppression, though no specifications are published on the performance of that filter.

The system provides for expandability and growth, with the 12-slot S-100 motherboard having eight spare slots after the standard plug-in boards have been installed. It should be easy to add an external hard disk system or other peripherals later. A memory larger than 64K is possible for multiuser or multitasking applications, since the system incorporates direct extended addressing to 2 megabytes. Morrow Designs also can provide their Micronix Operating System[4] (a UNIX[5] derivative) for multiuser environments. There even are provisions for installing a 6MHz Z80 processor or a future 16-bit processor.

All in all, the system has been designed to avoid early obsolescence, unlike many others that are limited to initial configurations or make future expansions impossible. Other systems often are obsolete within months, but the *Decision 1* is likely to be around for a long time because it can and does grow as the user's needs grow.

I've mentioned that my unit is a rack-mount configuration. That means it's a plain black box hanging from rails under my desk surface. And I do mean it's plain—there's no brand or manufacturer identification whatsoever on the front panel. However, the system is available in other configurations, with desktop units being more stylish and possibly more visually appealing. Desktop units range from $2,395 for a unit without disk drives, to $5,400 for one with a 5¼″ floppy disk plus a 16MB 5¼″ hard disk. For rack-mount unit prices, contact Morrow Designs.

I must cite at least one functional difference between the rack-mount unit I use and the desktop configurations. The rack-mount system controls are on the front panel, consisting of a red rocker-switch master power control and an illuminating red pushbutton switch that serves as the system reset and doubles as the power-on indicator. The desktop units have only the system reset pushbutton on the front, with the master power switch on the rear panel. The only reason I make a point of this is that the dealership has commented on some desktop users not liking the rear-panel power control. The *Decision 1* is just large enough to make it somewhat inconvenient to reach behind the system for power switching, but it certainly doesn't interfere with the overall operation.

In the first 25 weeks of running the system an average of 15 hours per day, seven days per week, there were no malfunctions. I saw a few BDOS errors, but only a half dozen or so were not due to operator error. Even those were "soft" in that a second try at reading the disk was successful. In all likelihood, the BDOS errors were caused by careless disk insertion, where the disks weren't properly seated and centered on the drive hubs. By comparison, the system the *Decision 1* replaced had some 35 service calls during its first eight weeks of operation, and continued at nearly that rate for most of its first six months. It's obvious that the *Decision 1* has much higher reliability.

Morrow Designs calls the *Decision 1* Rack Mount an "industrial grade computer package," a designation that should and usually does indicate a high-reliability unit. I did ask the factory representative for a "mean time between failures" (MTBF) figure since there wasn't one in their lit-

Ernest E. Mau, 3108 South Granby Way, Aurora, CO 80114

Desktop version of the Decision 1 with its terminal, overall view.

erature, but they indicated that sufficient statistical data had not yet been accumulated to determine an accurate MTBF. However, the representative said they anticipated achieving an MTBF exceeding 5,000 power-on hours. That's not bad if they make it!

From a user's view, the *Decision 1* is close to ideal. The dual double-sided 8″ floppies provide up to 2.2 megabytes of storage on line at any one time; the CPU and memory speeds are adequate for most applications; and disk accesses are surprisingly fast. Morrow Designs eliminated sector buffering by transferring data directly to memory via the DMA channel, so the CPU is free to proceed with other processing tasks during the disk transfers. Compared with my old computer, based on an 8080 CPU and comparatively slow access to 32-sector drives, there is an apparent increase in overall operating speed and throughput of about 6-to-1 for programs not requiring operator intervention during a run.

The physical construction is beautiful! Having grown accustomed to an older system packed with jumper wires, jury-rigged bypass circuits, sloppily soldered boards, and much general clutter, I was particularly impressed with the *Decision 1*. In the entire unit, I've found only one jumper wire (on the back of the MULT I/O board), indicating that the boards have been thoroughly tested and proven before being released to the market. I've been told that the systems were held off the market and shipment delayed for some months because there was a problem with one of the boards and the company didn't want to release units until the problem had been resolved.

There is no clutter. Interfacing ribbon cables to the four MULT I/O board connectors route cleanly from the top of the card to rear-panel connectors where the interface cables to the peripherals are attached—without interfering with other circuitry or boards. The boards themselves are works of art—clean design and clean soldering—obviously designed and manufactured with a good degree of pride.

Throughout, I've found the *Decision 1* a delight to own and operate. While I don't want to get carried away singing its praises, it certainly deserves them. To illustrate, there are many seemingly minor provisions that make life a lot easier for the user. Among these are:

- Software selection of the baud rates can be done independently for each of the three serial ports. The selection may be built into system or utility software like the CBIOS or a communication program, or performed individually with a BAUD program provided.
- Independently strappable signal assignments for all three serial ports are provided on the MULT I/O board. Depending on the CBIOS and other system requirements, changes from "data set" to "data terminal" operation, modem to non-modem communication, or for the individual RS-232C signal line assignments are easily implemented in the hardware.
- A special disk-formatting program called (FORMTDJ.COM) allows a choice of densities and sector sizes and also verifies the sectors of each formatted disk. On an 8″ system, disks can be formatted for either single or double density and then for 256, 512, or 1024 bytes per sector.
- The disk controller automatically adjusts to single-sided, double-sided, single-density, double-density, and sector size parameters of the inserted disk on booting the system. And it does so without the operator having to input any disk parameters from the keyboard. This allows a single-sided single-density CP/M

The Decision 1 is a thrill to use. It does everything I'd ever ask of a hard-working computer system, and has provisions for many more things than I ever expect to need.

distribution disk to be copied from Drive B to a double-sided, double-density disk in Drive A. It also allows writing single-density disks for distributing software in a standard format.

- A special SINGLE.COM program allows users having only a single drive to copy CP/M files from one disk to another. The program converts the one drive to a "logical" two-drive system and prompts for disk swaps as necessary to accomplish copying that otherwise could not be done with PIP.COM.

Documentation

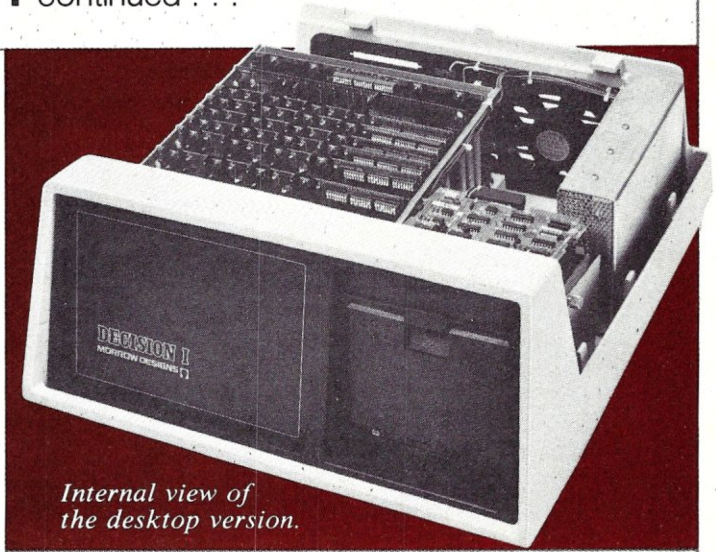
All these features and many more are included in the system. However, like any other computer, peripheral, or software product, the *Decision 1* does have some shortcomings that prospective users should recognize. The first and most easily recognized is that the hardware documentation is not oriented to the end user. The system comes with Morrow Designs' own reprints of the CP/M, BASIC-80, and WordStar manuals, plus a binder full of technical information on the system.

The latter item is exactly that, a technical manual, and it takes a technician to make much sense of it. It contains information that might be needed by a service technician, an advanced programmer, or a system designer integrating the unit into other OEM equipment. It does contain things like system schematics that would be invaluable for arranging"third-party" service or for modifying the system. However, it doesn't tell the end user how to get the system up and running. It briefly describes programs available on the system disk furnished, but it describes a disk with a different set of programs from the one I received.

The documentation does lack information about the switching power supply, linear power supply, and line filter. That could be a problem later, but I suppose the philosophy is that anyone needing such detailed information could obtain it from the original manufacturers of the power supplies.

Getting the system operational

The lack of effective user documentation gives rise to the most serious difficulty I've encountered—getting the system operational the first time through. The first problem I hit was formatting diskettes and recording the CP/M operating system on them. Running the Morrow formatting program had me facing a menu for selecting disk type (8″ obviously), single- or double-density (double looked good), the drive number, and then the bytes per sector. Coming from a single-format system and finding a choice of 256, 512, or 1024 bytes per sector sent me scrambling to find some information in the manual—it wasn't there. My first evening with the machine, I spent six hours trying to get a copy of the CP/M operating system onto a new disk formatted for 256 bytes per sector—unsuccessfully. I tried every combination of



Internal view of the desktop version.

MOVCPM, SYSGEN, DDT, and SAVE, and any other operations I could imagine, all with no luck. I then spent another two hours trying the same with a 512-byte disk. Finally, I got around to trying a 1024-byte disk, and it was the only format that worked.

Four weeks later, I happened to find two sentences in an on-disk information file I would never have read until after I had made a backup system disk. The statements explained that added features and functions increased the size of the Morrow CP/M system to exceed the capacity of the first two tracks of any disk formatted for other than 1024 bytes per sector. Therefore, CP/M can only be put on 1024-byte disks. Since that format is the most efficient data storage for the system (1.1 megabytes per disk), it's not particularly troublesome unless there's some special reason for wanting to use another format. Even then, about the only thing you can't do with other sector sizes is put on the CP/M operating system, so you can work with the others. I just wish the manual would have made a point of it and kept me from wasting hours.

Still, I didn't anticipate all the ramifications of an "oversize" CP/M. When I later tried to recompile some Basic programs transferred over from my older system, the Microsoft version 5.24 BASCOM[2] compiler and LINK-80[2] loader would run out of memory just a few seconds before completing the linking. The COM files from compilations done on the other machine could be run without difficulty; only the linking process was troublesome. As a result, I could not recompile and relink programs I had been using for years.

With BASIC-80 and some other tools as a check of free memory, I found the *Decision 1* was providing 3900 fewer memory bytes for program use than was my old system. That doesn't sound like a big deal, but my programs use maximum available memory for large data arrays and can't be shortened easily, so the loss of 6% of usable memory space did prove a problem. Finally, I had

Unlike many other systems limited to their initial configuration, the Decision 1 is designed to avoid early obsolescence.

to update the BASCOM/LINK-80 package to version 5.3 and use the "runtime" feature to arrive at a recompilation that would link the large files within the smaller memory. Ultimately that proved a real advantage because the runtime COM files are only half the size of the older COM files and allow much more efficient disk storage.

Disk drive considerations

The disk drives require some special consideration. I've stated that they can work with single-density disks or ones formatted as double density in 256-, 512-, or 1024-byte sectors, recognizing and automatically adjusting for the formatting of the disk in a drive at the time the system is cold or warm booted. They can read standard single-sided single-density (SSSD) disks and copy those to double-sided double-density (DSDD). They can even write data to an SSSD disk. However, in my system there was no provision for formatting SSSD media, and the single-density function of the FORMTDJ.COM program turned out to be double sided on double-sided drives. This meant that writing SSSD disks for distribution required having single-sided drives or using disks preformatted on some other machine's drives. According to Morrow, the failure to format SSSD disks resulted from an outdated PROM on the disk controller. When I installed a replacement PROM, formatting SSSD disks could be done normally.

I also had to grow accustomed to a delay between the completion of a disk operation and the time when I can remove the disk. It's a characteristic of the controller, the drives, or both that there's a 7- to 10-second delay between the end of a disk operation and the "in use" light going off. During that time, the drive doors are locked. The first time it caught me, I had just received the CP/M prompt back on the screen after a PIP copy, reached over and pressed the drive release, and nothing happened. Panic! I first thought the drive door had jammed. It hadn't! It's a normal feature, keeping the user from possibly damaging a disk while the drive is in use. Yet after four years on a system without such protection, I still get caught trying to remove a disk before it's allowed.

I've tested the *Decision 1* with a variety of commercial and custom software. As part of a series of book projects I've been preparing under contract to publishers, I've used 35 CP/M-based word processors and related programs, about a dozen disk and general system maintenance programs, and numerous other packages. All but two commercial packages ran successfully, and both "failures" were disk diagnostic or recovery programs that involved special disk handling. In both cases, I suspected a flaw in the software instead of the computer system—the programs didn't seem to read the disk-format information properly and subsequently malfunctioned when accessing the DSDD formats.

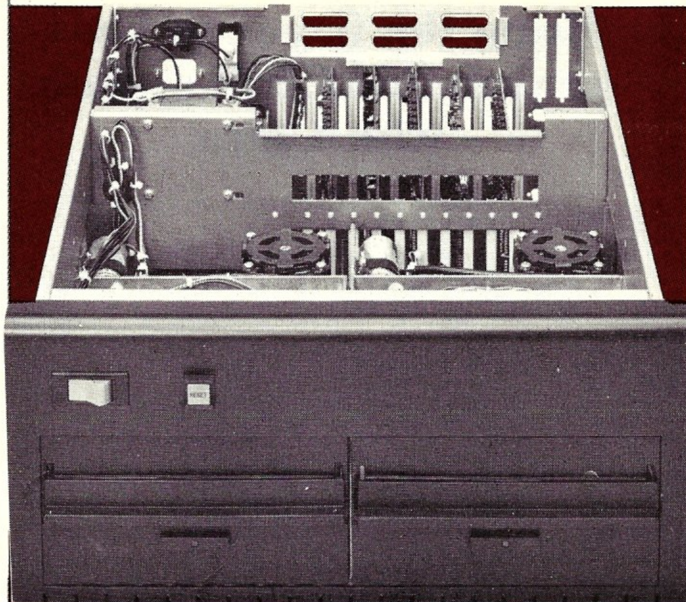
One problem program is Advanced Micro Techniques' DPatch[6], a useful utility providing direct disk alteration, direct file alteration, I/O ERROR file recovery, erased file recovery, and surface analysis. Only that last function fails. I like to do my own surface analysis or "certification" on every disk to minimize data losses. Even the sector verification function built into the Morrow formatting program doesn't satisfy me—I've had two bad sectors sneak past it and "trash" files on top-of-the-line premium-grade disks. I had hoped DPatch would prove a useful certification check; however, running the surface analysis registers hundreds of sector errors on a perfectly good disk. In fact, the function has never run to completion, eventually detecting what it "thinks" is a bad directory track and aborting because there's no way to store the bad-sector information.

The other program that fails is SuperSoft's Disk Doctor[7], a program designed to recover disk crashes or accidental file erasures. This one can't even be "installed" for the system. Any disk parameters fed into the installation routine generate errors at one point or another. I've talked to SuperSoft personnel, and they indicated they've been having trouble with other DSDD systems, and their new magazine advertisements specifically state that the program is not designed for double-sided disks. So once again, its a software problem rather than the fault of the *Decision 1*. I must point out, however, that I've experienced no problems with SuperSoft's Disk-Edit[7] or Diagnostics II[7] programs; both appear to operate properly with any disk format available on the system, and the Diagnostics II software gives me good assurance that the system is indeed functioning properly at all times.

One final observation concerns uninterruptible or standby power supplies. Since residential power in my locale is subject to frequent interruptions and brownouts, I want to equip the system with a suitable unit that would allow time for an orderly shutdown. So far, I've not found a workable, affordable unit. The ones I've tried either aren't powerful enough or generate an unusable output. The *Decision 1* is rated at 5.0 amps (about 550W) according to the back-panel label, with my complete system totalling 9.7 amps (about 1070W). Typical 200- or 400-watt (200VA or 400VA) supplies aren't enough. Even a 600W unit would support only the computer and drives, leaving me "blind" and helpless with no keyboard or display. Ideally, I need a 1200W (1.2KVA) or larger supply—an expensive proposition at best.

The situation is complicated by needing a sine-wave output from the uninterruptible or standby power supply. Several units on the market provide a square-wave output, but the ones I've tried have caused the internal regulated switching power supply of the *Decision 1* to oscillate and "buzz" loudly. A call to Morrow Designs' customer support

There is no clutter . . . The boards themselves are works of art—clean design and clean soldering—obviously designed and manufactured with a good degree of pride.



Rack-mount version of the Decision 1, internal view. Controls are on the front panel.

has informed me that the system "probably" can't tolerate a square-wave input and that attempts to use such could prove destructive. However, that has not been confirmed by the system engineers, so I can only advise extreme caution in installing power backups.

Even with these few difficulties, the *Decision 1* has been a thrill to use. It does everything I'd ever ask of a hard-working computer system and has provisions for many more things than I ever expect to need. I don't anticipate any situation where the system will be unable to accommodate my business operations.

In short, anyone in the market for an expandable, reliable, state-of-the-art computer system would be well advised to look at the *Decision 1*. Additional information and lists of local dealers are readily available from Morrow Designs, 600 McCormick St., San Leandro, CA 94577; (415) 430-1970.

Notes

1. The Decision 1 is a trademark of Morrow Designs.

BASIC-80, BASCOM, and LINK-80 are trademarks of Microsoft.

3. WordStar is a registered trademark of MicroPro International.

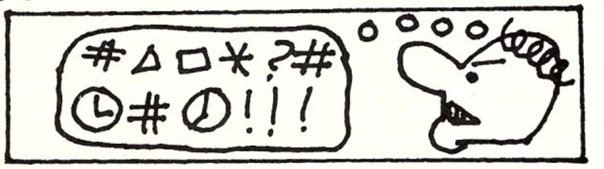
4. Disk Jockey and Micronix Operating System are registered trademarks of Morrow Designs.

5. UNIX is a registered trademark of Bell Laboratories.

6. DPatch is a trademark of Advanced Micro Techniques.

7. Disk Doctor, Disk-Edit, and Diagnostics II are trademarks of SuperSoft, Inc.

BDOS ERROR ON B:BAD SECTOR



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- BADLIM checks thoroughly your disk marking all the blocks which have defective sectors. The operating system will know that those sectors should be skipped.
- BADLIM is the only program that gives protection for soft and hard errors.
- The first time BADLIM will list which files in your disk are on bad sectors, so you can take action to correct it.
- But thereafter the bad areas in your disk will be automatically by-passed.
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BADLIM cost only $73. Whatever the reason you have to use a computer you need BADLIM. Contact your dealer or call us today:

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DEALER INQUIRIES INVITED. **BADLIM**

CIRCLE 57 ON READER SERVICE CARD

EXPAND YOUR CP/M OPERATING SYSTEM WITH SCP/80

SCP/80 IS AN ENHANCEMENT OF THE CP/M 2.2 OPERATING SYSTEM

BUILT IN FEATURES INCLUDE

• WORKS WITH MOST ANY TERMINAL	• CP/M FILE COMPATIBLE
• EASY INSTALLATION	• BUILT IN CP/M "HELP" AIDS
• OVER 50 COMMANDS AND AIDS	• OPTIONAL BELL WITH PROMPT
• DISPLAYS CURRENT MEMORY MAP	• BUILT IN DIS-ASSEMBLER
• HEX MATH CALCULATOR	• LOG TERMINAL TO A FILE
• DISPLAY MAP OF INPUT PORTS	• PRINT NOTES ON PRINTER
• MEMORY BLOCK MOVE	• MEMORY BLOCK COMPARE
• MEMORY BLOCK SEARCH ASCII	• MEMORY BLOCK SEARCH HEX
• MEMORY TEST	• MEMORY FILL WITH CONSTANT
• MEMORY ENTER ASCII	• MEMORY ENTER HEX
• MODIFY MEMORY	• DUMP DISK TO CRT HEX/ASCII
• SAVE FILE OF ANY MEMORY BLOCK	• LOAD FILE ANY WHERE IN TPA
• PRINT ASCII FILES W/TITLE	• TYPE ASCII FILES
• DIR W/ORDERED LIST W/PARAMETERS	• CONVERT ASCII/HEX ON CRT
• CRT TEST PATTERN	• PRINTER TEST PATTERN
• CONVERT ABSOLUTE TO HEX FILE	• ERASE CRT SCREEN
• CONVERT HEX TO ABSOLUTE FILE	• CHANGE DISK
• USER COMMANDS MAY BE ADDED	• AUTO COMMAND
• NO TPA LOSS FOR APPLICATION USE	• PIP MENU
• NO CBIOS CHANGES ARE REQUIRED	• CLEAR TPA FEATURE
• MOST COMMANDS CAN BE BATCHED	• BATCH (SUBMIT) OPERATION

SCP/80 IS SUPPLIED ON 8" CP/M DISK WITH MANUAL

A.B. HUTCHISON ENGINEERING — **ALLOW 20 DAYS**
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(305) 943-1530

CIRCLE 47 ON READER SERVICE CARD

Bring the flavor of Unix to your Z80 CP/M system with Unica

"Unicum: a thing unique in its kind, especially an example of writing. Unica: the plural of unicum."

The Unica: a unique collection of programs supporting many features of the Unix operating system never before available under CP/M. The Unica are more than software tools; they are finely crafted instruments of surgical quality. Some of the Unica are:

bc	binary file compare, display differences in hex
cat	catenate files (vertically)
cp	copy one or more files, even between users
dm	disk mapper, reports free blocks and directory space
fid	file identification by unique numbers (CRC's)
hc	horizontal file catenation and column permutation
ln	create file links (multiple names for one file)
ls	intelligent directory lister, optional multi-columns
mv	move (rename) files, even between users
rm	remove (delete) files, with optional verification
sc	source file compare, with resynchronization
sfa	set/reset file attributes, optional verification
sp	spelling error corrector, with 80,000 word dictionary
sr	search multiple files for a pattern
srt	in-memory file sorter, optional duplicate line omission
tee	pipe fitting (copy input stream to multiple outputs)
tr	transliterate (translate character codes)
wc	word counter, counts characters, words, and lines
wx	word extractor, copies each word to a separate line

Each Unicum understands several flags ("options" or "switches") which control program alternatives. No special "shell" is needed; Unica commands are typed to the standard CP/M command interpreter. The Unica package supports several Unix-like facilities, such as filename user numbers:

```
sc data.bas;2 data.bas;3
```

(compares files belonging to user 2 and user 3);
Wildcard patterns:

```
rm -v *tmp*
```

(types each filename containing the letters TMP and asks whether to delete the file);
I/O redirection:

```
ls -a >proj.dir
```

(writes a directory listing of all files to file "proj.dir");
Pipes:

```
dm b: | sr free >lst:
```

(creates a map of disk B:, extracts those lines in the map which contain the word "free", and prints them on the listing device).

The Unica are written in XM-80, a low level language which combines rigorously checked procedure definition and invocation with the versatility of Z80 assembly language. XM-80 includes a language translator which turns XM-80 programs into source code for MACRO-80, the industry standard assembler from Microsoft. It also includes a MACRO-80 object library with over forty "software components", subroutine packages which are called to perform services such as piping, wildcard matching, output formatting, and device-independent I/O with buffers of any size from 1 to 64k bytes.

The source code for each Unicum main program (but not for the software component library) is provided. With the Unica and XM-80, you can customize each utility to your installation, and write your own applications quickly and efficiently. Programs which you write using XM-80 components are not subject to any licensing fee.

Extensive documentation includes tutorials, reference manuals, individual spec sheets for each component, and thorough descriptions of each Unicum.

Update policy: each Unica owner is informed when new Unica or components become available. At any time, and as often as you like, you can return the distribution disk with a $10 handling fee and get the current versions of the Unica and XM-80, with documentation for all new or changed software.

The Unica and XM-80 (which requires MACRO-80) are priced at $195, or $25 for the documentation. The Unica alone are supplied as *.COM executable files and are priced at $95 for the set, or $15 for the documentation. Software is distributed only on 8" floppy disks for Z80 CP/M version 2 systems. All orders must be paid in advance; no COD's or purchase orders, please. Quantity discounts are available. Shipment outside of the US or Canada costs an additional $20. Bank checks must be in US funds drawn on a US bank.

Knowlogy
P.O. Box 283-A
Wilsonville, Oregon 97070

Visa/Mastercard customers call (503) 639-3420 for next day shipment.

CP/M is a trademark of Digital Research. Unicum and Unica are trademarks of Knowlogy. Unix is a trademark of Bell Telephone Labs. XM-80 is a trademark of Scientific Enterprises. Z80 is a trademark of Zilog Inc.

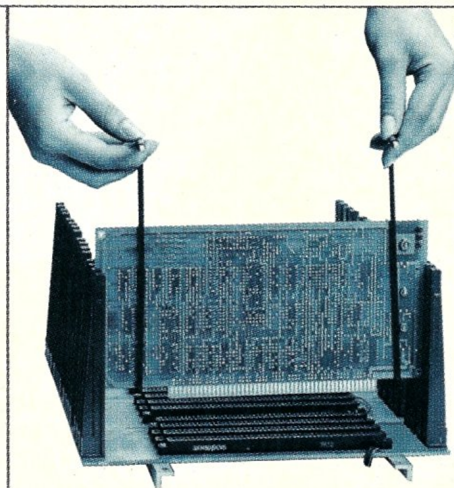
Hooking Made Easy

An inexpensive S-100 circuit card extractor

by Kenneth M. Piggott

If you're the owner of an S-100 system or any system with a circuit card cage and motherboard arrangement, you have probably encountered difficulties when one of your system's circuit cards had to be removed. Very few of the S-100 circuit cards have ejection ears to aid in their removal from the card cage. Unfortunately, even fewer card cages have provisions for using the ejector ears. To complicate matters even further, the S-100 card cage is based on ¾″ spacing between circuit cards, resulting in a difficult time for fingers as they try to grasp the circuit cards. To remedy the situation, I devised a pair of simple card extractors.

Each card extractor is made by bending an 18″ length of 1/8 x 3/16 aluminum welding rod into a "T" with a hook (see Figure 1). I purchased a 36″ aluminum welding rod at a hobby shop for 30¢. When constructing the card extractors, make a 90° bend at (A). Then slide an 8″ piece of heat-shrink tubing down the long portion and work it around the hook. When the entire hook is covered, shrink the tubing. Then make a 90° bend at (B) and a 180° bend at (C) and (D). To finish the card extractor, slide a 2″ piece of heat-shrink over each half of the Tee-handle and shrink the tubing.



To use, simply slide a card extractor down the rear side of each end of the circuit card, hook under the circuit card and apply a gentle rocking, upward pull. The circuit card will slide out easily for user access. If the card extractors are to be used with cards other than the S-100 type, the 7½″ dimension should be adjusted for the particular cards used.

Kenneth M. Piggott, 16166 Chesterfield, East Detroit, MI 48021

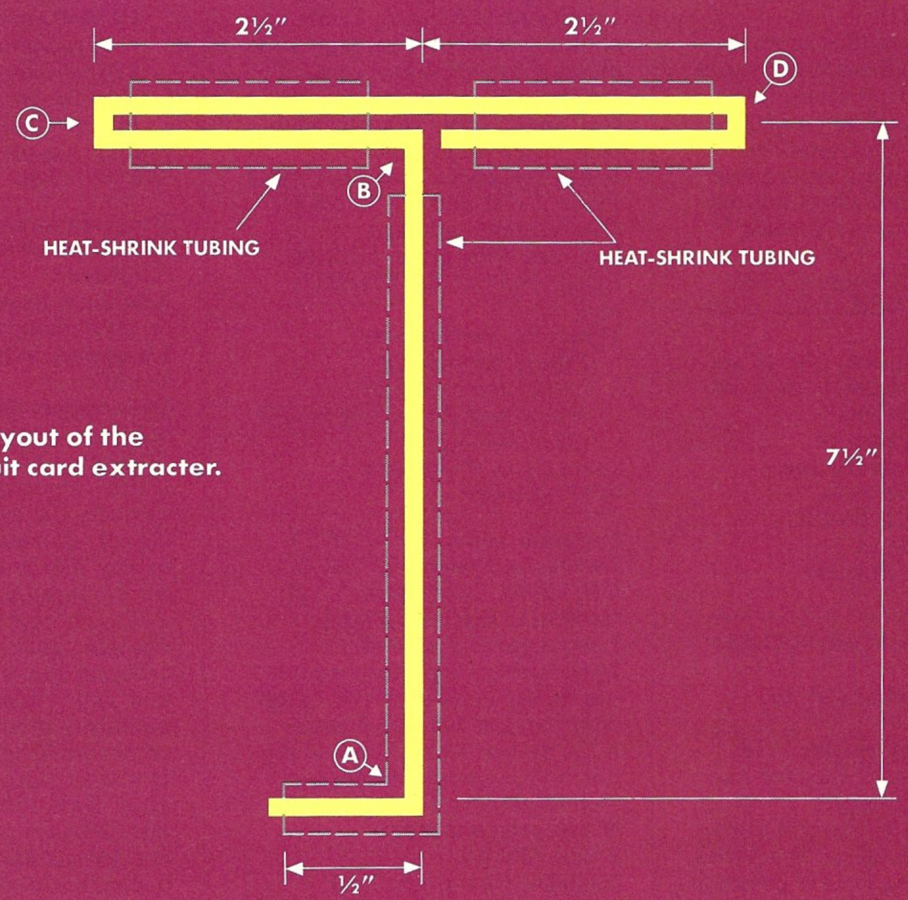
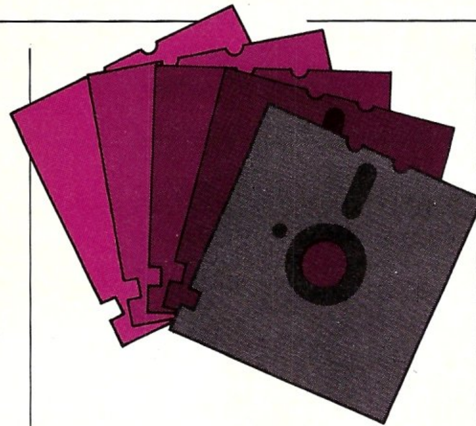


Figure 1.
Physical layout of the
S-100 circuit card extracter.

Software Directory



Program name: MultI/NET
Hardware system: Z80, 8080, 8085
Minimum memory size: 32K
Language: Assembly
Description: MultI/NET is a logical extension to MultI/OS, UNI/OS, and I/OS. MultI/NET broadens InfoSoft's line of functions from single-user through single-CPU multiuser to complete network containing any mix of single-user and multiuser CPUs.

The basic structure of MultI/NET follows the ISO open system interconnect structure, with the interunit message structure allowing flexible protocols. Some features of the system architecture are: Network nodes can be either single user with disk, single user without disk, or multiuser with disk. Shared resources, such as disks and printers, operate as a server for the network nodes. Multiple servers and users can be set up at the same location using MultI/OS.

Standard facilities include: Directory, subdirectory, remote task, password protection, interunit file transfer, multiple printers (both local and remote), file sharing, record/file lock, remote disk, directory assigning, and remote spooler control.
When released: August 1982
Price: $300; OEM prices available on request.
Included with price: No. of stations (1-255) depends on hardware configuration.
Where to purchase it:
InfoSoft Systems, Inc.
80 Washington St.
Norwalk, CT 06854
(213) 866-8833
CIRCLE #159 ON READER SERVICE CARD

Program name: Tarbell Database System
Hardware system: CP/M, MP/M
Minimum memory size: 48K
Language: CBasic (source and .COM files provided).
Description: The Tarbell Database System consists of a series of programs that use a common file format for random and sequential files with optional index files. The main menu program chains to other programs and to HELP files. Nineteen files may be open with no limit on record length or number of records. Field names may be any length.

A QUERY language that may be used interactively or written in command files allows the user to define search area and scope or search, as well as conditions to be met. It includes a report writer that uses most of the QUERY commands, a file copy program, sort, mail label, and personalized letter programs.
When released: December 1982
Price: $100 plus $1.50 S&H; CA residents add tax.
Included with price: Disk (8" SD or North Star SD/DD) and manual.
Where to purchase it:
Elliam Associates
24000 Bessemer St.
Woodland Hills, CA 91367
(213) 348-4278
CIRCLE #160 ON READER SERVICE CARD

Program name: CPMGREP
Hardware system: CP/M-80, CP/M-86, Cromemco 5", SuperBrain, IMB-PC, Apple
Language: Object code.
Description: A pattern-matching utility similar to the "grep" command of UNIX. Recognizes patterns and can use regular expressions. Includes a free dictionary file.
When released: 1980
Price: $29.95
Included with price: Disk
Where to purchase it:
AGS
Box 366
Englishtown, NJ 07726
CIRCLE #161 ON READER SERVICE CARD

Program name: HexPrintR
Hardware system: CP/M with WordStar 2.26 or 3.0
Minimum memory size: 48K
Language: Assembly
Description: HexPrintR is a modifier to WordStar which allows the user to send any codes at all (even 8-bit codes) to his printer. It does this by modifying the printer control code ^R. For example, "^R1B, 0R" would send an Escape followed by a null. HexPrintR is available in Osborne, Attacke, NEC, and IBM 3740 formats.
When released: April 1982
Price: $39 delivered.
Included with price: Installation disk, 40-page manual, and demo files.
Where to purchase it:
CI Software & Computer Products
1380 Garnet Ave., E149
San Diego, CA 92109
(619) 483-6384
CIRCLE #162 ON READER SERVICE CARD

Program name: DES-Crypt
Hardware system: CP/M-80, CP/M-86
Minimum memory size: 36K or user memory
Language: 8080 and 8086 assembly
Description: Des-Crypt is a software implementation of the NBS data encryption standard (DES) algorithm. DES-Crypt protects the privacy and integrity of information contained in any file. It includes functions for encryption, decryption, verifying encryption, data authentication, destroying plaintext, creating hex keys, comparing and listing files. DES-Crypt is menu-oriented with extensive error checking and on-line help. It accepts either hex or ASCII keys. Data authentication function is based on cryptographic checksums and can be used independently of encryption to

protect files against undetected accidental changes or deliberate tampering. It encrypts/decrypts at 40-60KB/min. Convenience/safety features include: default file names, ambiguous file names, automatic maintenance test, optional checksums on hex keys, redundant key entry (with or without screen echo); first block of all ciphertext files automatically verified.
When released: December 1982
Price: $149
Included with price: Disk, documentation, support
Where to purchase it:
Trigram Systems
3 Bayard Rd. #66
Pittsburgh, PA 15213
(412) 682-2192
CIRCLE #163 ON READER SERVICE CARD

Program: BOBCAT
Hardware system: CP/M Z80, 8080
Minimum memory: 48K
Language: Object code
Description: BOBCAT is a very user-friendly disk catalog program that takes all the work out of keeping track of disk contents. It creates, adds, deletes, and updates catalog entries. It provides four report formats sorted either alphabetically or numerically. It has three date format options of MM/DD/YY, DD/MM/YY or YY/MM/DD, and a selectable reminder date for updating. The program automatically numbers disks and provides for disk titles in the catalog. BOBCAT is written in PL/I.
When released: Sept. 1982
Price: U.S. residents, $25 USD; Canadian residents, $25 CDN; other countries, $30 USD; all postpaid.
What is included with price: 8″ standard CP/M SSSD disk and 21-page documentation.
Where to purchase it:
R & L Micro Consulting Services
6 Lipstan Ave
Nepean, Ontario
Canada K2E 5Z3
(613) 225-7904
CIRCLE #164 ON READER SERVICE CARD

International Software Directory
A reference source giving extensive details of over 10,000 packaged software products from major software houses throughout the world. Two volumes are available: Vol. 1 for microcomputer software, Vol. 2 for minicomputer software. Each is fully indexed for Computer Model, Application (Subject), Operating System, Language, Program Name, and Software House. The database is also accessible on-line internationally through the Lockheed Dialog Information Service. An annual update subscription service is available.
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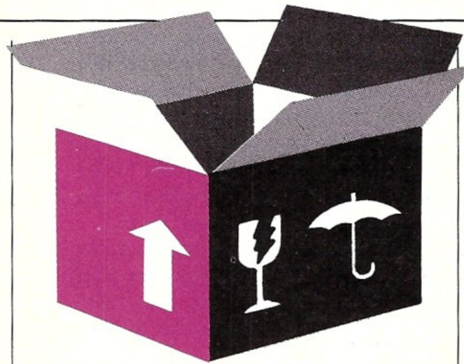
Fort Collins, CO 80524
(800) 525-4955;
CIRCLE #165 ON READER SERVICE CARD

New Products



Portable computer

ACCESS is a complete portable computer system with all the peripherals integrated into a single compact unit. Designed for business, education, professional and home use, ACCESS has the features, capabilities, and versatility to handle every application.

ACCESS contains a high-speed dot matrix printer, a direct-connect modular telephone jack and acoustical coupler, a 7″ amber monitor, two high-performance double-density 5¼″ disk drives, a low-profile detachable keyboard, 64K of user memory, a Z80Z central microprocessor, a comprehensive software package, multiple I/O ports, a storage compartment for 10 diskettes, and a leather carrying case. All are standard features.

The ACCESS built-in printer delivers quality hard copy at a rate of 80 characters per second. Users can print up to 132 characters per line on standard 8½″ paper. In addition to the 96 ASCII character set, there are graphic capabilities as well. A program included in the software package allows various type styles to be printed.

The internal modem, adjustable for 0-300 baud, gives the utmost in telecommunications capabilities and flexibility. There is a direct line modular telephone jack as well as an acoustical coupler. There are four operating modes: manual originate, manual answer, automatic dialing, and directory support. The 7″ amber screen displays 80 characters per line on 24 lines. An extra 25th line has been included as a status line. Data and time information are available on the status line. The screen has several user-selectable attributes: inverse, blink blank, underline, double underline, half intensity and normal intensity.

ACCESS has one parallel port that is Centronics compatible or bidirectional, one fully implemented IEEE 488 port, and two RS-232C serial ports with software-selectable buad rates up to 9600.

The two 5¼″ single-sided double-density disk drives provide 184KB of data storage per disk. Offered as an option are double-sided double-density disk drives for a total of 736KB of disk storage. ACCESS also supports two external 8″ disk drives.

Included in ACCESS' software package are CP/M 2.2., Perfect Writer, Speller, Filer, and Calc. Fancy Font by Softcraft provides various type style selections. MBasic from Microsoft, CB-80 from Digital Research, and a communications package are also included.

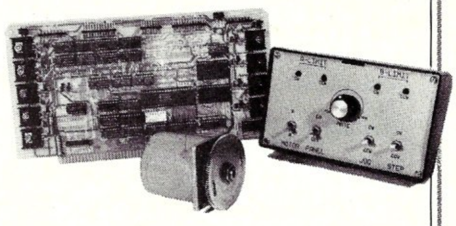
Price: $2495.

Access Matrix Corporation, 2159 Bering Drive, San Jose, CA 95131; (408) 263-3660.
CIRCLE #166 ON READER SERVICE CARD

S-100 stepper controller

The MC100 motor controller system consists of an S-100 controller card, a manual control panel, and CP/M driver software. Of the many options available to the system designer for controlling digital motors, the MC100 is the only one designed specifically for S-100 computers. This fact allows reduction of the total system cost because the motor control function is integrated within the computer chassis and does not require a separate stand-alone unit.

The MC100 will directly drive two moderate-power four-phase motors. The universal translator interface allows higher power motors to be controlled by the system. Other significant features of the system include motor ramping, automatic limit sensing, and internal or external step pulse count functions.



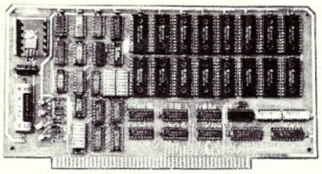
The controller is a 5″ × 10″ card and is fully compliant with the IEEE-696 standard for interfact to the S-100 bus. The manual control panel measures 6″ × 4″ and gives the user control of motor step and variable jog rates in either direction.

The CP/M-compatible software package for the MC100 allows complete control of all system features with a simple software interface which may be accessed from Basic, Fortran, or assembly language programs.

Prices: controller (A&T), $350; manual control panel (optional), $135; CP/M driver software, $35; MC103 (combination of above), $449.

Snow Micro Systems, Inc., P.O. Box 2201, Fairfax, VA 22033; (703) 378-7257.
CIRCLE #167 ON READER SERVICE CARD

BATTERY BACKUP 32K
CMOS RAM/EPROM
S-100 MEMORY BOARD
8 or 16 BIT DATA PATH
$199 KIT, $279 A&T



- 6MHZ
- bank select
- phantom option
- activity indicator
- IEEE 696 (S-100) compatible
- extended addressing switch selectable
- all address and data lines are buffered
- window selection at 2K boundary
- EPROM can be mixed with RAM

Yang Electronic Systems, Inc.

307 Compton Avenue, Laurel, MD 20707

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CIRCLE 232 ON READER SERVICE CARD

GET FULL VALUE FROM YOUR VICTOR 9000™

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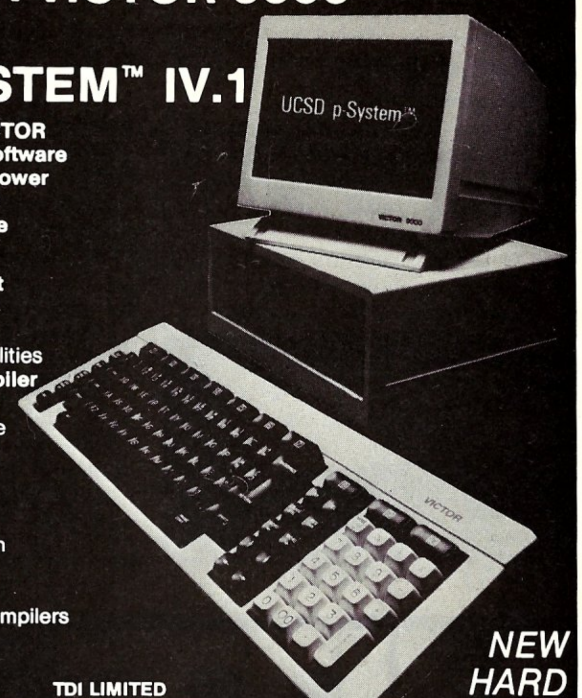

Get the most from your VICTOR 9000 as well as from your software development efforts. The power and portability of the UCSD p-System is available for the VICTOR 9000 from TDI.

The Standard Development System Includes:

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CIRCLE 219 ON READER SERVICE CARD

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Hunstville,
AL 35801

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At A Great Price!

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- S100 compatible board with jacks for microphone, speaker
- Unlimited vocabulary - record and store any words or messages
- Switch selectable data rates 1.5, 2, 2.25, 3, 4k bytes/second
- Complete manual with software source code listings

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Manual only (credit on first order)	$11.50

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COMPUPRO SYSTEM A	5495.	4295
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COMPUPRO SYSTEM C	8995.	7195
SEATTLE GAZELLE	5995.	4395.
PRINTERS:		
DIABLO 620	1595.	1175.
NEC 3510, 3515	1995.	1385.
OKIDATA 83-A	995.	707.
OKIDATA 84-A	1395.	995.
TERMINALS:		
HAZELTINE ESPRIT I	595.	489.
TVI 925	995.	725.
TVI 950	1195.	925.
VISUAL 200	1295.	975.
VISUAL 300	1195.	975.
VISUAL 50	745.	675.

	LIST	MMW
8″ MS-DOS SOFTWARE:		
MS-DOS 1.2X IO.ASM FOR COMPUPRO DISK I & SCP CARDS (MMW/COMPUVIEW PRODUCTS)	150.	135.
ASCOM (DMA-THE ULTIMATE MODEM PROGRAM)	195.	160.
ASHTON-TATE DBASE II-86	700.	420.
MICROSOFT MULTIPLAN	500.	345.
MICROSOFT BASCOM 86	400.	270.
MICROSOFT FORTRAN77	400.	270.
MICROSOFT PASCAL	400.	270.
EM-86 (LIFEBOAT)	75.	70.
SUPERCALC 86 (RUNS W/EMULATOR-86!!!)	295.	165.
SORCIM SUPERWRITER (BETTER THAN WORD*!)	395.	247.
COMPUVIEW VEDIT-86	195.	175.
PERFECT WRITER (PERFECT SOFTWARE)	395.	280.
WATFIV FORTRAN '66 (SUPERSOFT)	425.	325.
S-100 EQUIPMENT:		
COMPUPRO 256-K (STATIC) MDRIVE)	1595.	1445.
PARADYNAMICS PRONTO	1595.	1355.
HAYES SMARTMODEM (1200 BAUD)	695.	549.
TEI DFD-0 (DEMO)	595.	445.
COMPUPRO APPROVED 20 MB HD SUBSYSTEM	3695.	3295.

TAPE DRIVES, SEATTLE & COMPUPRO CARDS, NORTH STAR ADVANTAGE, MS-DOS FOR COMPUPRO 8/16 SYSTEMS, ETC. **IT'S HERE! CALL!!!**
TERMS: COD CERTIFIED CHECK OR CORPORATE PURCHASE ORDER W/BANK REFERENCE

CIRCLE 85 ON READER SERVICE CARD

New Products continued . . .

Compact S-100 computer

California Computer Systems, Inc., has announced the Slimline 3000, an 8-bit general-purpose microcomputer with 16-bit upgrade capability. Contained in a single 19″ cabinet, it can be desktop or rack-mounted.

The Slimline 3000 includes

S-100 bus compatibility, Z80 CPU, high-density 5¼″ Winchester disk, dual floppy disk capability, expansion to 1024 K RAM, 27 MB hard disk, and 20MB streaming tape cartridge drive. It comes with CP/M; Oasis and MP/M are available for multiuser support and may be upgraded for 8 users.

Price: 16 configurations available: $4,295-$10,995.

California Computer Systems, Inc., 250 Caribbean Dr., Sunnyvale, CA 94086; (408) 734-5811.

CIRCLE #168 ON READER SERVICE CARD

OSBAUD

The OSBAUD baud rate generator allows the Osborne 1 user the versatility of baud rates from 50 to 19,200 (1200 baud is the maximum available from the standard Osborne 1). The 16 different baud rates are switch-selectable via a dip-switch accessible through the front panel of the Osborne 1.

OSBAUD is a small auxiliary circuit board attached via four terminals that solder directly to four corresponding points on the main circuit board of the Osborne 1 computer. One circuit trace must

Unlock the Door to Progress.

Move up to the speed and power of a **true** 16 bit Key Micro System S-100 Computer. Unlock the door to *your* future now with a Key Micro System.

KEY SYSTEM 16

Assembled and unit tested using CompuPro boards

- CPU 8086 (10 Mhz)
- 128k memory (16 bit wide)
- 3 serial 2 parallel I/O ports
- DMA Floppy Controller
- 2 DD DS 8" Floppy Drives in enclosure with power supply and cables
- 20 slot S-100 Enclosure
- CP/M 86

$5195.00

KEY SYSTEM 16H10

The same as KEY System 16 but includes one 8" DD DS Floppy and one 10 Mb 8" Hard Disk instead of two Floppies.

$7595.00

•

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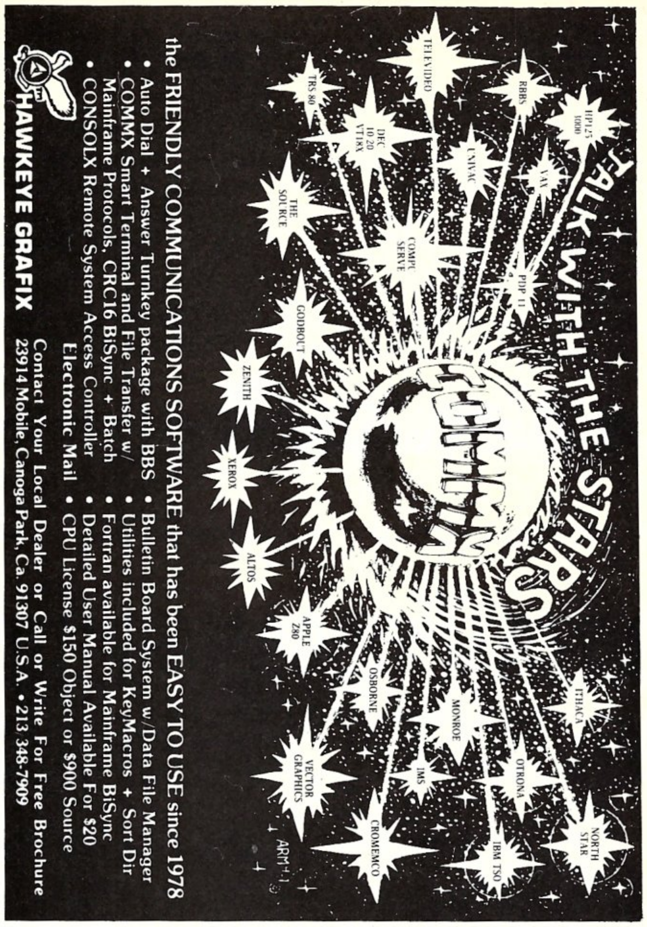

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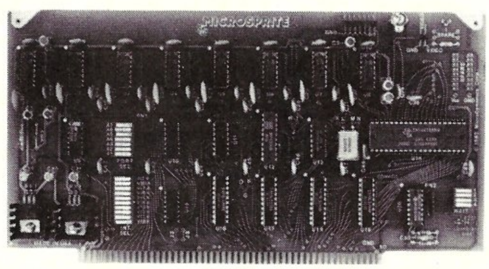

- Display consists of backdrop and pattern planes plus 32 sprite planes; each pixel in a plane can be colored or transparent to reveal the underlying plane(s); 16 colors (including transparent) are available.
- Four display modes:
  1) TEXT—twenty-four 40-character rows in two colors. 2) MULTICOLOR—64H x 48V pixels; each pixel can be one of 16 colors. 3) GRAPHICS I—256H x 192V pixels; each 8 x 8 group of pixels can contain two different colors; all 16 colors can be on screen simultaneously. 4) GRAPHICS II—256H x 192V pixels; each horizontal group of 8 pixels can contain two different colors; all 16 colors can be on screen simultaneously.
- Composite video output connects directly to color monitor or RF modulator.
- On-board 16K RAM occupies *no* system memory space; board uses only two I/O ports.
- Uses powerful Texas Instruments TMS9918A Video Display Processor; DIP switch selection of 0-4 wait states, I/O port numbers and vertical retrace interrupt options.
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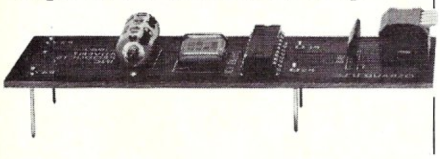
be cut to disable the standard Osborne 1 baud rate generator. The installer has the option of making a small opening in the front panel of the Osborne 1 if repeated access to the dip-switches is desired, or replacing the front panel unaltered. Time required for installation is approximately 30 minutes.



Price: $59.95; includes installation instructions and 1-year warrantee.

Advent Products, Inc., 965 N. Main St., Orange, CA 92667; (714) 997-0800.
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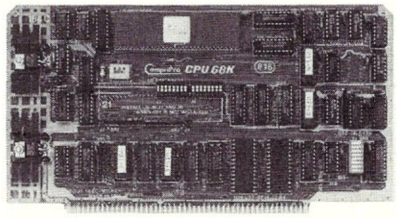
68000 S-100 CPU board

CompuPro has introduced a 10MHz CPU board based on the 68000 microprocessor, designated CPU 68K, that accesses a full 16MB of nonsegmented memory available on the IEEE 696-S-100 bus. The CPU 68K handles both 8- and 16-bit memory and permits mixing of both types in the same system. The board can change from full speed to half-speed operation with a simple jumper change.

It includes a socket for the 68451 Memory Management Unit, and sockets for up to 16KB of EPROM (8K x 16), and accept 2716, 2732, or 2764-type EPROMS. There is a provision for power-on jump using EPROMs.



An on-board wait state generator accommodates all types of machine operations, and as many as five waits can be added to any cycle.

An on-board interrupt structure works with either the internal vector-generation circuitry or an external source.

Fully compatible with CompuPro's entire IEEE-696/S-100 bus product line, CPU 68K is capable of sharing the bus with CompuPro slave processors in order to run 8-bit or 16-bit

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Price: CPU 68K, $695 (8MHz); $850 (10MHz CSC). Optional FORTH OS: $200.

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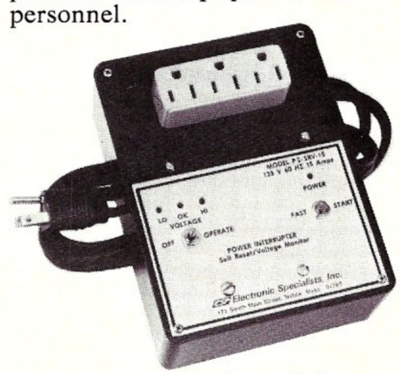

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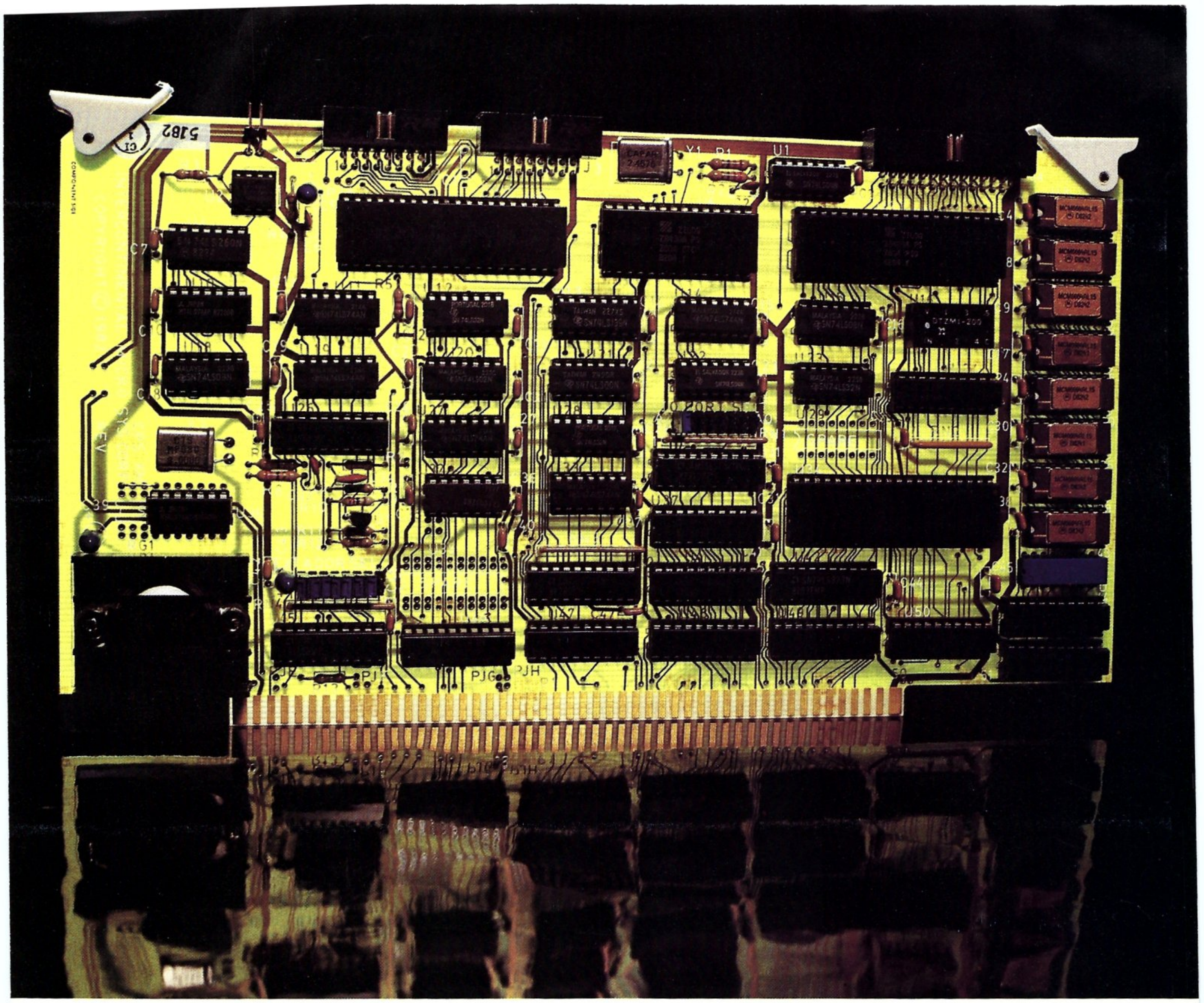

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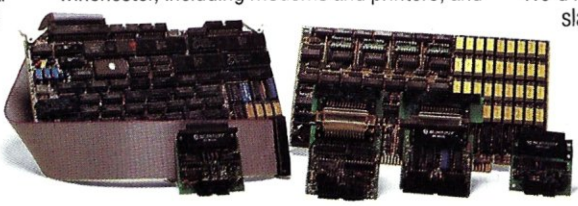

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